DOCUMENT RESUME

ED 338 758 UD 028 382

AUTHOR Beane, DeAnna Banks
TITLE Mathematics and Science: Critical Filters for the Future of Minority Students.
INSTITUTION American Univ., Washington, DC. Mid-Atlantic Equity Center.
SPONS AGENCY Department of Education, Washington, DC.
PUB DATE 88
CONTRACT G00840178
NOTE 68p.
PUB TYPE Guides - Non-Classroom Use (055) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Academic Achievement; American Indians; Black Students; Demonstration Programs; Educational Change; *Educational Improvement; Elementary Education; Guidelines; Hispanic Americans; Intervention; *Mathematics Education; Measures (Individuals); *Minority Group Children; Principals; *Science Education

ABSTRACT

This manual presents a guide to enhancing elementary school level mathematics and science education for minorities in order to improve their chances of advancing in an educational program that will enable them to enter employment in technical fields. In particular, the manual aims to fulfill the following purposes: (1) review the role of the principal in effecting change; (2) provide elementary principals and instructional personnel with data and background information about factors underlying the underrepresentation of Blacks, Hispanic Americans, and Native Americans in advanced mathematics and science courses; (3) describe significant components of successful programs addressing this underrepresentation; (4) provide materials that facilitate assessment and intervention planning; and (5) present resources that support prevention and intervention strategies at the local school level. Seven tables provide pertinent data. The National Science Board Commission on Precollege Education in Mathematics, Science and Technology's paper, "Suggestions for Course Topics and Criteria for Selection," is appended. Eighty-nine references are included. (JB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

UD

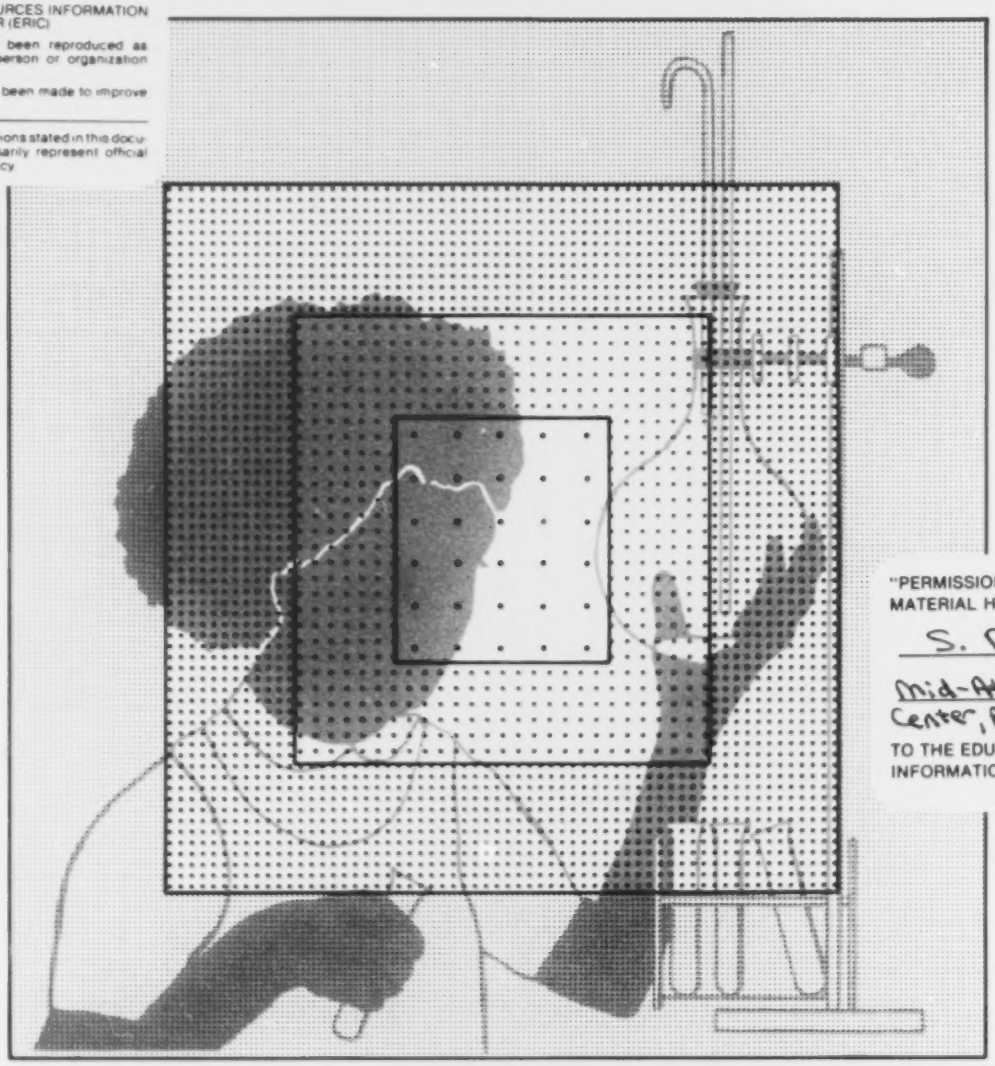
Mathematics and Science

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.



"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

S. Denbo

Mid-Atlantic Equity Center, Am. University

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED338758

Critical Filters for the Future

UD 028 382

BEST COPY AVAILABLE

Mathematics and Science: Critical Filters for the Future of Minority Students

Developed by
DeAnna Banks Beane

The Mid-Atlantic Equity Center
The American University
5010 Wisconsin Ave., N.W.
Suite 310
Washington, D.C. 20016
(202) 885-8517

1985

1988

UP85-318X

Dedication

This publication is dedicated to the memory of the late Ransellear Shorter whose work with the Mid-Atlantic Center for Race Equity laid the foundation for this project.

Acknowledgments

The preparation of this publication required the cooperation of many individuals who generously contributed their time, expertise and resources. Special appreciation must be extended to the director and staff of the Mid-Atlantic Center for Race Equity for the way in which they demonstrated their commitment to this issue through their continued patience and encouragement.

A warm thank you to Marlene Ross for the editing, M. Teresa Peters for the typing and Suzi Gifford for the cover design.

The contract development of *Mathematics and Science: Critical Filters for the Future of Minority Students* was funded by Title IV, Section 403, of the Civil Rights Act of 1964 (P.L. 88-352), G00840178, U.S. Department of Education. However, the opinions expressed in this publication do not necessarily reflect the position or policy of the U.S. Department of Education, and no official endorsement by the Department of Education should be inferred.

Discrimination Prohibited—No person in the United States shall, on the basis of race, color, or national origin, be excluded from participation in, or be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance, or be so treated on the basis of sex under most education programs or activities receiving Federal assistance.

The American University is an Equal Opportunity/ Affirmative Action Employer.

"Probably the single greatest contribution which early education in science can make to a people is the development of a belief based on evidence, that they can to some extent influence the direction and quality of their destiny."

Mary Budd Rowe, "Relation of Wait-Time and Rewards to the Development of Language, Logic and Fate Control: Part II—Rewards," *Journal of Research in Science Teaching* 11 (1974): 299.

Table of Contents

I. **Introduction** 1

II. **To the Principal** 3

The Effective School 3
The Effective Principal 3
The Principal as Change Agent 4
Developing Effective Teachers 4
The Intervention Plan 5
For Further Reading 5

III. **Factors Influencing Minority Student Participation and Performance** 7

Students: Affective Factors 8
Attitudes toward Mathematics and Science
Stereotyping of Mathematics and Science
Perceived Utility of Mathematics and Science
Influence of Significant Others
Persistence

Students: Cognitive Factors 11
Previous Experiences
Academic Deficiencies
Language
Misuse of Testing/Test Data
Learning Styles

Classroom Factors: Cognitive and Affective 16
Teacher Expectations
Teacher Anxiety: Mathematics
Teacher Anxiety: Science
Instructional Practices

Summary and Implications 19

IV. **Intervention Strategies and Programs** 25

A Positive Classroom Climate 25
Teacher Expectations
Learning Atmosphere
Social Organization

Intervention Programs 26
Components of Successful Programs
Successful Program Strategies
Effective Utilization of Community Resources
Examples of Intervention Programs

V. **Getting Started: Tools for Assessment and Planning** 29

A Leader's Model for Planning Equity Intervention 29
Checklist for Equity in Mathematics and Science 30
Form for Elementary Mathematics Achievement Test Data 33
Form for Elementary Science Achievement Test Data 34
Form for Secondary School Course Enrollment Data 35

VI. Resources for Intervention 36
Educational Programs 36
Science Intervention
Mathematics Intervention
Cooperative Learning
Thinking Skills
Career Motivation 40
Language 41
Bias in Instructional Materials 41
Teacher Expectations (Staff Development Programs) 42
Learning Styles 42
Teacher Anxiety in Mathematics and Science 43
Professional Organizations (Sources for Role Models) 45

References 47

Appendix

Table I 53
Mathematics and Science Courses of High School Seniors by Racial/Ethnic Group and Course Title: 1980

Table II 54
Scholastic Aptitude Test (SAT) Scores for College Bound Seniors by Race/Ethnic Group: 1976-82

Table III 55
Changes in Mean Performance on the Mathematics Assessment by Racial/Ethnic Group: 1978-82

Table IV 56
Changes in Mean Performance for Males and Females on the Science Assessment by Race: 1977-82

Table V 57
On Campus Recruitment, Average Opening Job Offers from January 1981 by Field and Mathematics Requirement

Table VI 58
SAT Averages and Average Family Income for 1973-74 College Bound Seniors

Figure 59
Instructional Model for Second Language Approach to Mathematics Skills (SLAMS)

Curriculum Recommendations from the Report of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology 60

I
Introduction

Minority unemployment has been reaching record breaking highs. Simultaneously, newspaper headlines about the computer revolution, which is bringing structural unemployment along with severe labor shortages in technical areas, remind us of the increasing employment opportunities available in scientific fields. While major efforts have been made to encourage all students to consider scientific careers, minorities are still severely underrepresented in those areas (National Science Foundation, 1984).

Selection begins considerably before it is time for students to choose a career. In 1973, sociologist Lucy Sells identified mathematics as the "critical filter" when she demonstrated the consequences of inadequate mathematics preparation for women. Significantly more males than females had taken the necessary high school mathematics to enter the calculus sequence in college. Since calculus is required for undergraduates majoring in engineering and the natural sciences, female students' access to these fields was limited. More recent research has identified a similar state of affairs for minority students who are severely underrepresented in advanced mathematics and science classes in high school. Black and Hispanic students are scoring below the national norm on science and mathematics achievement tests and are not enrolling in advanced high school mathematics classes in proportion to their numbers in the population (NAEP, 1983; Peng, Fetters, and Kolstad, 1981; see Appendix Tables I and II). Because mathematics is a sequential subject and most science and science-related positions require a mathematics background, minority students must be encouraged to begin their mathematics education early and to continue through high school at a minimum.

The success of many intervention programs demonstrates that there are no permanent barriers to minority student achievement in science and mathematics. However, the data tell us that the longer we wait to intervene the more invincible the barriers become. Programs have been mounted to increase minority participation in mathematics at the secondary level, but insufficient attention has been given to the role of the elementary school instructional program in the subsequent underrepresentation of minorities in advanced mathematics and science courses. As Mathews (1981) pointed out, "If we examine the current programs and research we will find that most of those efforts are targeted for minority students in the sixth grade through the college level. There appears to be little emphasis on the early grades. It is as though we do not look for ways to fill the cup until the cup is half empty" (p.3).

This resource manual has several purposes:

(1) to review the role of the principal in effecting change

(2) to provide elementary principals and instructional personnel with data and background information about factors underlying the underrepresentation of Blacks, Hispanics and Native Americans in advanced mathematics and science courses

(3) to describe significant components of successful programs addressing this underrepresentation

(4) to provide materials which facilitate assessment and intervention planning

(5) to present resources which support prevention and intervention strategies at the local school level

II
To The Principal

The Effective School

This period in American public education has been marked by a rising public and professional cry for clear standards of excellence, especially in mathematics and science. Many researchers and educators concerned with improving the quality of public education argue that achieving and maintaining equity in the educational process must be an essential component of any quest for excellence. Recent research on schools with high achievement for most students, regardless of their family backgrounds, has provided us with insight into the common elements of effective schools. Such schools provide:

- strong instructional leadership from the principal
- clear objectives
- high expectations for all students
- recognition and reward for good work
- firm, fair but infrequent discipline
- accessible teachers and administrators
- an appropriate measurement system for monitoring student achievement

In addition...

...the staff of effective schools firmly believes that all students can master the common set of curriculum objectives and that all students can achieve.

...the students in effective schools believe that they are capable of achieving (high academic self-concept) and that what they do will make a difference in school and in their lives.

...parental involvement in effective schools is designed by the school to facilitate the school's achievement goals.

The Effective Principal

Effective schools are led by effective principals! Research tells us that in comparison with their ineffective counterparts, effective administrators conduct more observations of teachers in the classroom. They provide more support for teacher improvement efforts and are more active in establishing effective teacher and program evaluation procedures (Bossert et al., 1982). Among the prerequisites which have been identified as essential to effective principal behavior are:

- knowledge and skills concerning effective teaching and curricular practices
- goal setting
- decision making
- resource mobilization and allocation
- staff and program evaluation
- staff development (Cohen, 1982)

What is the role of the elementary school principal in improving minority student achievement in mathematics and science? Lortie (1982) found that 75% of the principals he interviewed gain their major satisfaction from evidence that their students are achieving. We know that minority students are being filtered out of the mainstream of advanced science and mathematics by a number of factors, many of which are discussed in the following section. Research findings are pointing to the elementary school as the most effective place to intervene in order to build on positive attitudes, break stereotypical images, develop a strong academic self-concept, and master basic concepts and skills in mathematics and science. The earlier intervention begins in elementary school, the greater the chances for success.

An effective principal employs all of the effective principal behaviors described above to organize and maintain mathematics and science programs which promote both excellence and equity for all students. Such a leader recognizes the importance of mathematics competency for all children, and values science not only for its content, but also for its contribution to the cognitive development of all children.

The Principal as Change Agent

Resourcefulness and commitment are needed if change is to occur, and the first step toward intervention is assessment of the status quo. The reality of minority student underachievement in science and mathematics provides an opportunity to do a complete assessment of the total school mathematics and science programs.* Such assessments will yield information about areas in need of improvement (equity, instructional programs, curriculum and instructional materials, teacher support and competency, staff development, student performance and resources). Staff involvement, even in these initial stages, may make development and implementation of an intervention plan easier. Section V includes several instruments designed to facilitate the process of assessing a school which is developing intervention plans in the areas of mathematics and science:

a. A Leader's Model for Planning Equity Intervention Programs

b. Checklist for Equity in Mathematics and Science developed by the Mid-Atlantic Center for Race Equity

c. Form for Elementary Mathematics Achievement Test Data

d. Form for Elementary Science Achievement Test Data

e. Form for Secondary School Course Enrollment Data

Developing Effective Teachers

Since mathematics has long been a part of most school district testing programs, it has remained a top priority in the elementary curriculum. Science, on the other hand, has practically disappeared from many elementary classrooms, especially activity-based science. For elementary school principals committed to the goal of improving minority student performance and participation in these disciplines, the greatest challenge may accompany intervention efforts in the science programs.

Over two-thirds of all the teachers participating in a national survey perceived deficiencies in science content and science teaching methods as barriers to effective science teaching (Maben, 1980). The message here is clear: if minority students are going to demonstrate a higher level of achievement and participation in science and mathematics, most of their teachers—urban, suburban and rural—will need strong support systems. Much of this can be accomplished through well-planned inservice programs which help teachers to:

a. expand their knowledge of science or mathematics content

b. feel comfortable with the "hands on" activities through practice sessions

c. devise effective classroom management techniques

d. develop competence in a variety of instructional methods

e. plan instructional strategies to meet a variety of learning style needs

f. resolve problems as they occur

g. develop mechanisms for informally monitoring the participation of their minority students

As discussed later in this publication, an integral component in any school intervention plan will be the effective use of structured activity-based curricula in mathematics and science. This necessitates training for teachers before and during the implementation stages. The data continue to underscore the positive correlation that exists between teacher training prior to and during implementation of a new program and successful outcomes in terms of student achievement. While the principal can assume responsibility for a lot of the inservice training, it will probably be necessary to call on the assistance of the mathematics and science resource teachers, other teachers who may have already received the special training, a local college of education, or the commercial affiliate from whom curriculum materials are being purchased. Before implementing any pro-

---

* Recommended school program assessment instruments are found in:

The National Council of Teachers of Mathematics, *How to Evaluate Your Mathematics Program* (Reston, Va.: The National Council of Teachers of Mathematics, 1981).

K. Mechling and D. Oliver, *Handbook III Characteristics of a Good Elementary Science Program Part A: Principal's Checklist of Characteristics* (Washington, D.C.: Project for Promoting Science Among Elementary School Principals, National Science Teachers Association, 1983).

gram to improve minority student performance in mathematics and science, sufficient time must be set aside to:

a. acquaint teachers with the problem and with the long-term consequences of minority student underachievement

b. explore the contributing factors. (This may result in teachers expressing the need to understand more about the cultures of their minority students.)

c. encourage the participation of teachers in science and mathematics program assessments, to determine their effectiveness for all children

d. involve teachers in the selection of appropriate classroom intervention strategies and in the development of school-wide intervention programs

The Intervention Plan

Many minority students, even at the elementary level, are placed in remedial groups, especially in mathematics and reading. According to Rosenbaum's research (1976), homogeneous or ability grouping tends to restrict academic upward mobility; movement between tracks is usually downward, which is certainly counter to the goal of improved achievement. Brookover et al. (1982) maintain that staff expectations are influenced by and reflected in the school's grouping patterns and the resulting differentiated objectives. Such grouping policies communicate different learning expectations to students. Those who have been placed in the remedial or "slower" groups usually absorb the implied message: we consider you a slower learner and we do not expect you to accomplish as much as those in the higher group. The student then performs accordingly. By the time this student reaches sixth or seventh grade, neither the student nor the teacher nor the counselor expects placement in the pre-algebra track.

In the discussion of the influence of significant others on minority student participation in mathematics and science (see page 9), many minority women scientists identified their early start in preparatory classes as critical to their later success in advanced mathematics and science courses. But students who become locked into remedial or general track classes are usually unable to exercise the opinion of taking geometry, Algebra II or pre-calculus because of the time spent in remediation and general courses required for graduation.

An effective minority student intervention program must break the cycle of low expectations, poor performance, remediation, and low self-concept which then generates more low expectations. An intervention program must be far more comprehensive than a class to improve minority children's basic arithmetic skills. In fact, such a class will probably exacerbate the situation.

Intervention plans usually focus on

a. strategies designed to address the mathematics/science barriers experienced by the general minority population

b. strategies to identify and support minority students with previously demonstrated high performance in mathematics and science

The emphasis in this manual is on (a)—the underachieving minority student. However, Section IV lists several intervention programs which may serve as models for the development of type (b) intervention plans. The strategies discussed throughout the manual have been recommended because of their effectiveness in increasing motivation and improving performance. No single instructional strategy can be equally effective with all students, even if they are all members of the same minority group. If a school has already introduced one of the strategies suggested here, but without the desired results, the factors discussed in Section III should be reviewed. Any effective intervention plan will require the incorporation of several of these strategies. Section IV lists the components and strategies for successful intervention programs.

For Further Reading

Bossert, S.; Dwyer, D.; Rowa, B.; and Lee, G. "The Instructional Management Role of the Principal." *Educational Administration Quarterly* 18 (Summer 1982): 34-64.

Brookover, W.; Beamer, L.; Efthim, H.; Hathaway, D.; Lezotte, L.; Miller, S.; Passalacqua, J.; and Tornatzky, L. *Creating Effective Schools: An Inservice Program for Enhancing School Learning Climate and Achievement.* Holmes Beach, Fl.: Learning Publications, Inc., 1982.

Cohen, M., and Manasse, A. "Effective Principals." *The School Administrator* 30 (November 1982): 14-16.

Denbo, S., and Ross, M. *The Effective Principal.* Washington, D.C.: Mid-Atlantic Center for Race Equity, The American University, 1983.

The Effective School Report—From Research and Practice. Published monthly by Kelwynn, Inc., P.O. Box 2058, Grand Central Station, New York, N.Y., 10163.

Lortie, D. "Elementary Principals in Suburbia: An Occupational and Organizational Study." Draft report to the National Institute of Education, 1982. Cited by Cohen, M., and Manasse, A. in "Effective Principals." *The School Administrator* 30 (November 1982): 14-16.

Maben, J.W. "Is There Hope for School Science in the 1980's?" *National Elementary Principal* 59 (January 1980): 37-43.

Rosenbaum, J. *Making Inequality: The Hidden Curriculum of High School Tracking.* New York: John Wiley & Sons, 1976.

III
Factors Influencing Minority Student Participation and Performance

Researchers studying racial discrepancy in the learning of or participation in mathematics and science have identified several affective, cognitive and instructional variables which affect minority student performance:

Students: Affective Factors

- Attitudes toward Mathematics and Science
- Stereotyping of Mathematics and Science
- Perceived Utility and Mathematics and Science
- Influence of Significant Others
- Persistence

Students: Cognitive Factors

- Previous Experiences
- Academic Deficiencies
- Language
- Misuse of Testing/Test Data
- Learning Styles

Classroom Factors: Cognitive and Affective

- Teacher Expectations
- Teacher Anxiety: Mathematics
- Teacher Anxiety: Science
- Instructional Practices

Students: Affective Factors

The first set of factors to be explored here are those which evolve out of the minority student's emotional or social state as it relates to mathematics and science.

• Student Attitudes Toward Mathematics and Science

Although the achievement scores for Black and Hispanic students are still below the national level (see Appendix Tables III and IV), the findings of independent researchers (Anick, 1982; Kahle, 1982) as well as data from the National Assessment of Educational Progress in both mathematics and science (NAEP 1979, 1983) tell us that in elementary school these same minority students

(a) do like mathematics and science

(b) find both disciplines interesting

(c) have little anxiety about these subjects

(d) would like to study more mathematics and science

Furthermore, responses by 17 year olds to certain attitudinal items on the NAEP: Science (1979) indicated that Black students maintain their interest in science longer than their white counterparts (see "Attitude" in Table IV). Valverde (1984) reports a situation for Hispanic students similar to that of Blacks: students value science but this is reflected neither in their achievement nor in their continued participation.

Unfortunately, the positive attitudes which support a math/science affinity in the early grades are gradually overshadowed by a number of other factors as minority children progress through the intermediate and middle or junior high school years. The common pattern of behavior becomes math avoidance which closes the door to successful participation in high school chemistry and physics courses (see Appendix Table I).

• Stereotyping of Mathematics and Science

Evidence suggests that some minority students may hold racial stereotypes; that is, they may perceive both mathematics and science as white domains (Hall, 1981; Kenschaft, 1981). Some minorities hold perceptions of scientists and mathematicians as being highly intellectual, inflexible and socially isolated—traits which may not be highly valued in their cultures (Olstad, 1981). Additionally, it is difficult for many minority children to visualize a future for themselves in science or technology because most of the minority role models in the media—especially television—have been athletes, musicians, comics, domestics, law enforcement officers and low-level support personnel. Such stereotyping helps to create a low academic self-concept projected through the attitude of "I'm not smart enough to do well in science."

Furthermore, Fennema (1982) argues that since our society stereotypes mathematics as a male domain, female students receive and internalize this message. Such a disabling message may be communicated through textbook problems which depict girls struggling with shopping or cooking tasks, or in any number of other ways. Traditionally males have been depicted as being generally competent in mathematics, utilizing it for a wide variety of activities. Many parents, counselors, and teachers believe that mathematics is more important for boys than for girls.

The effect of race and sex stereotyping appears to be most serious on minority girls, even those who are high achievers. By the time minority girls reach junior high or middle school, many who were achievers in elementary school science begin to demonstrate low self-concepts in science as evidenced by passive behaviors in laboratory activities (Jacobowitz, 1983). The impact becomes even more evident a litte later as we observe minority girls, with science and mathematics scores similar to those

of boys, choosing not to prepare for mathematics or science-related careers.

• Perceived Utility of Mathematics and Science

Minority students are less likely to know how mathematics and science will be useful to them for their future jobs or schooling. They tend to think of mathematics as a classroom "pencil and paper" exercise, totally unrelated to everyday experiences (Matthews, 1984). Some students may live in an environment in which scientists are viewed with distrust. Negative images of science and scientists may result in insufficient cultural support for the continued study and application of science concepts.

• Influence of Significant Others

Teachers, guidance counselors and parents contribute to minority student attitudes about themselves in relation to mathematics and science (Hall, 1981; Kenschaft, 1981). Teachers and counselors who communicate the genuine expectation of high achievement and success to minority children and to their parents can have strong positive effects on the students' attitudes, academic self-concepts and performance in mathematics and science. Such genuinely-held high expectations can not be merely verbal communications, but must be backed up with a multitude of supportive, positive behaviors on the part of the educator. (The role of teacher expectations is discussed later in greater detail under "Classroom Factors.")

Minority students have indicated a strong preference for teachers who are willing to work with them, giving extra help, explaining carefully and providing encouragement (Fernandez et al., 1975; Matthews, 1980; Treisman, 1982). Minority women scientists, when asked to recall factors which contributed to their decisions to enroll in advanced classes in high school, identified the following as most significant: small classes, and an early start in the prerequisite courses which enabled them to later select and succeed in these advanced courses (Hall, 1981; Malcom, Hall and Brown, 1976). Those students who, as early as fifth, sixth or seventh grade, are discouraged from preparing for algebra and geometry, are being handicapped in terms of their later educational and occupational options. Counselors who promote the early tracking of minority students into general, vocational or remedial programs are projecting low expectations not only to the students, but to the parents and teachers of these students as well.

The positive potential of peer influence is often overlooked. A study of exemplary intervention programs for minorities and females (Office of Opportunities in Science, 1983) found that many of the most successful programs recognize and nurture the supportive and cooperative aspect of peer relationships.

• Persistence

Those who are most successful in mathematics and science have developed the ability to persevere when faced with a challenge. The 1977 NAEP: Science (1979) included a question designed to elicit information on persistence in thirteen year olds: "How often do you keep working on a task even if you run into problems that you didn't expect?" Of the responding Black thirteen year olds, 43% replied always or often (Kahle, 1979). The responses of over half of the Black participants indicated that, in problem solving situations, these students tend to give up when confronted with opposition.

Rowe (1974, 1977) strongly suggests that there is a relationship between a student's sense of control over his or her fate and that student's degree of persistence in the problem solving process. Rotter (1966), Brooks and Hounshell (1975), Lefcourt (1976) and others have also explored the "locus of control" factor in their studies of variables which impact on learning and achievement. An individual's locus of control can be described as the extent to which that individual accepts personal responsibility for what happens to him or her. An individual who believes that the positive and negative events encountered are contingent upon his or her own behavior is characterized as having an internal locus of control. Such students have been found to demonstrate higher achievement in science (Burow, 1978). Those who believe that they have no control over what happens to them, and who usually attribute happenings to luck, other people or environmental circumstances, are

characterized as having an external locus of control.

Several factors, including minority group membership and socioeconomic status, have been suggested as contributing to an individual's locus of control orientation. Discriminatory practices in education, politics, housing and the labor market affect the feeling of power (Lefcourt, 1966; Joe, 1971; Battle and Rotter, 1963). Members of social groups with limited power tend to score higher in externality on locus of control scales. This is also true for persons who face environmental and economic barriers.

Historically, the Black, Hispanic and Native American populations have felt that they have had minimum control over their fate; many of today's minority students reflect that legacy with an external locus of control. A high proportion of these students do not believe that there is a logical explanation for natural phenomena, as evidenced by their responses in the National Assessment of Science. Students who believe that they have no control over the events in their lives, may have difficulty remaining with a challenge or problem until it is solved. It is difficult for such students to believe that what they do can actually make a difference in the outcome of a problem, project, experiment, or grade. Curriculum interventions designed to help young children look for logical causal relationships in nature are likely to help these same students look for logical cause and effect explanations in the events of their own lives.

There appears to be a relationship between academic success and development of an internal locus of control. Olstad (1981) describes a project reported by DeCharmes in which Black teachers in an urban school designed a three-year intervention program for Black economically disadvantaged students. This training program consisted of classroom experiences that promoted realistic goal-setting, achievement motivation, self-confidence, personal responsibility and increased awareness of personal causation. Traditionally on achievement tests, there had been a progressive increase in the discrepancy between national norms and performance by these particular students. This pattern of declining achievement was broken during the three-year intervention program, and the indicators showed a shift toward the development of an internal locus of control for the participants.

To succeed in mathematics and science, students must not only persist when challenged, but also must develop a mind set that seeks logical explanations for natural occurrences and for the events in their lives. Mathematics and science programs should be structured to foster the development of an internal locus of control.

Rowe's research suggests effective classroom methods for promoting the development of internality. She has demonstrated that teachers can make a marked difference by

(1) allowing students sufficient time to think before answering questions

(2) engaging in behaviors which do not dominate classroom interactions thus fostering independence and

(3) providing many structured problem solving experiences requiring students to hypothesize cause and effect relationships

From Rowe's work we can infer that the quality and quantity of a child's early experiences in mathematics and science do affect that child's sense of control over his or her academic fate. Children with early, successful involvement in rich experiences are more likely to later develop attitudes which lead to the assumption of responsibility for changing personally unrewarding conditions. If a young child is given varied opportunities to manipulate materials and conditions as components of problem solving experiences, it is more likely that he or she will later manifest an attitude of "I know that if I work at this, I can do it."

Students: Cognitive Factors

In addition to those factors which contribute to the attitudinal component of minority students' underachievement in mathematics and science, several factors related to the acquisition of information and the development of thinking skills have been suggested by the research.

• Previous Experiences

In the discussion of affective factors, it was pointed out that in spite of their positive attitudes toward science, Black elementary students score below the national norm in science skills (NAEP: Science, 1979). The data tell us that ethnic minority children generally perform well on science test items for which they have an experiential base; that is, they respond best to items directly related to their daily lives (NAEP: Science, 1979). Their responses to certain items on these surveys indicate significant deficits in the actual school and community science experiences of Black students (Kahle, 1982). Black 9-year-olds are far behind white children when it comes to common experiences like observing the birth of an animal, the sprouting of a seed, ants or bees working or visiting a museum or zoo.

In terms of academic performance measures, the data indicate that generally the more mathematics and science a minority student has studied, the better he or she will perform on achievement tests. As the test scores improve, so does the student's academic self-image (Olstad, 1981).

• Academic Deficiencies

While Black and Hispanic students have made significant gains in the areas of computational skills and mathematical knowledge, there are still deficiencies in understanding and application of concepts (see Appendix Table III). It appears that the basic drills of remedial mathematics have paid off, but we must move on to help students develop proficiency in translating and solving word problems.

Educational, environmental and cultural factors may be responsible for the pattern of minority student success being tied to daily life and common knowledge experiences. However, to improve their general performance in science, it is imperative that minority students participate in carefully planned experiences designed to build basic skills in science so that they can

a. recognize problem situations (problem identification)

b. develop procedures for addressing the problem (organizing resources)

c. recognize and evaluate solutions to problems (formulating and testing hypotheses)

d. apply solutions

(The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983)

An effective elementary school program must include an emphasis on both the content and the process skills which help children learn how to learn. The cumulative results of comparative studies of activity-based science programs and teacher/text-based programs may provide a light through the tunnel for those who are serious about improving minority student achievement. These studies, involving 13,000 students in 1000 classrooms, found that students in activity-based science programs, showed substantial improvement in science process skills and creativity, when compared to students in teacher/text-based programs. Students in activity-based science programs also showed improvement in the areas of science content, perception, logic, language development and mathematics, and expressed more positive attitudes toward science (Bredderman, 1982; Shymansky, Kyle and Alport, 1982).

The gains made by economically or educationally disadvantaged students who were in activity-based science programs were quite striking. These students showed an average gain of 34 percentile units over the control

group on assessment of science process skills (observing, classifying, communicating, measuring, hypothesizing, predicting, inferring, designing investigations, collecting and analyzing data, and drawing conclusions). The disadvantaged students also showed average gains of 20 percentile units over the control group on assessments of science content and 12 percentile units in logic development (Bredderman, 1982).

Real success in science relies heavily on the development of the "ability to formulate questions about nature and seek answers from observation and interpretation of natural phenomena" (The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983). Only through exercises which support the development of these kinds of skills can minority students see value in the objective, research attitudes on which scientific careers and scientific literacy are based.

• Language

Communication systems are essential not only among the individuals of any one group, but also between different groups. Language is the vehicle by which information is transmitted and received. This manifestation of a group's culture embodies those symbols and sets of symbols used in that culture to label, define and convey ideas. Smith (1981) in writing about Navajo students suggests that the style of a language influences the student's approach to learning and applying mathematical concepts. If a student has a culture, language, and/or language pattern that differs from the majority or mainstream culture, linguistic bias in the classroom is inevitable.

Research has demonstrated that there is a high correlation between reading ability and mathematics achievement (Aiken, 1972). Some researchers argue that intelligence, achievement and personality tests are really assessments of language proficiency which is a function of culture. This makes the reliability of such instruments questionable for students of limited proficiency in standard English. Many educators working with students with limited proficiency in English maintain that instruction in two languages (bilingual education) is most effective if basic concepts and skills are learned in the primary language, then transferred to English. It can be hypothesized that in successful bilingual programs, student achievement is increased when initial instructional time is spent mastering the concepts and skills appropriate for the grade level, using the words and syntax systems of the student's primary language. This would certainly appear to be a significant factor in solving word problems in mathematics.

Several researchers (Trevino, 1968; Coffland and Cuevas, 1979; DeAvila, Duncan, Ulibarri and Fleming, 1979) have found that Spanish-speaking children who are taught mathematics in bilingual programs score higher on mathematics assessments than Spanish-speaking children who are taught exclusively in English. In reporting their study of the relationship between language skills and quantitative skills of older bilingual students, Mestre, Greace and Lockhead (1982) discuss the anxiety generated when students are confronted with a group of words which are individually familiar, but collectively comprise a word problem of little or no meaning to them. Their work with bilingual students led them to conclude that bilingual students benefit from

a. programs which increase their language proficiency

b. direct instruction in problem solving with an emphasis on "linguistic deciphering"

Cuevas (1984) has developed an instructional model ("The Second Language Approach to Mathematical Skills") for dealing with English as a second language in the mathematics classroom. For each mathematics objective in the curriculum, he proposes a series of sequential teacher behaviors which focus on both the mathematics skills and relevant language skills (see figure in Appendix).

In a study of the inquiry approach to the teaching of science and language to bilingual third graders, Rodriguez and Bethel (1983) found that inquiry methods improved the children's oral communication skills and their ability to classify information and objects at the abstract or conceptual level. During each lesson every child in the experimental group was given tasks which involved manipulation of concrete objects, exploration and interaction with the teacher. Working independently or in small groups, children discovered relationships as they talked and manipulated the objects. Rodriguez and Bethel concluded that activity-

based inquiry science lessons are effective vehicles for accomplishing both linguistic objectives and science process skills objectives. Their findings reinforce the previously discussed findings of studies of activity-based science programs (Bredderman, 1982).

While discussing this ideal approach to educating language minority students, it must be recognized that for many schools it may be extraordinarily difficult to provide teachers who are proficient enough in the various languages to use the bilingual approach in teaching the basic skills. Some schools have established a class in English for speakers of other languages. The students, regardless of their primary language, spend an hour or two a day in a special class learning to speak, read and write English. These students then return to the English-speaking classroom where their teachers must constantly remember that while all of their students are being challenged to master new concepts, some of them are also struggling with the general linguistic context of the concepts. For the student and teacher, this consumes instructional time, and may contribute to a lowered self-concept for the student. An ongoing concern must be whether the teacher's instructional message is the message actually received and internalized by the student. For these students, achievement may not be a reflection of ability in mathematics and science, but rather an indication of the extent to which language barriers interfere with learning.

• Misuses of Testing/Test Data

Although neurological and genetic factors have been suggested to account for the underachievement of ethnic minorities in mathematics and science, there is no hard evidence on which to base such conjectures (Kamin, 1973). On the contrary, results of Piagetian-based tests of children of varying ages and ethnic groups support the notion of intelligence equally distributed across ethnic and cultural populations.

The subtle factors of language and cultural bias are consistently overlooked when discussing the performance of ethnic minorities on standardized tests. Cultural and/or class bias in pictures, words or concepts is one serious danger inherent in standardized testing but inaccurate data for underachieving minority students also result from using assessment instruments which

- do not measure that which they purport to measure
- have been normed on a group that is racially or sexually different from the students in a specific classroom
- are not based on the school curriculum or
- measure a child's disability rather than actual progress (Kaser, 1984)

Scholastic Aptitude Test (SAT) scores are commonly used by schools and colleges as indicators of student ability. The SAT scores of Blacks, Hispanics and Native Americans have been consistently lower than those of white students (see Appendix Table II). Educational Testing Service, developer and administrator of the SAT and other standardized tests, has reported a direct correlation between family income and SAT scores (see Appendix Table VI).

Begle's study (1972) of pre- and post-test scores for seventh grade mathematics students of different cultural backgrounds has important implications for test data usage. A battery of standardized pre- and post-tests was given to two classes of Hispanic students. The scores were then compared with the scores of white seventh graders for the same test battery. For the white students, pre-test scores correlated with performance on the post-test. For the Hispanic students, however, the post-test performance did not correlate with pre-test data. The Hispanic students' achievement was greater than expected (if the pre-test was used an a predictor). Although the standardized test could have been used to accurately predict the achievement of white students, it would have been a serious mistake to use the tests to either predict the achievement of the Hispanic students or to place them in ability groups.

• Learning Styles

Information from research on learning styles reveals the need to recognize and understand cultural differences as we plan for academic intervention. However, we must constantly remind ourselves that "all stereotyping on the basis of race or ethnicity can be counterproductive because being a member of a particular ethnic group does not necessarily mean cultural distinctiveness" (Olstad, 1981). The findings from any study, no matter how valid, cannot be applied to *all* members of any ethnic group

because of variations in the degree of acculturation, differences within groups and differences within families. With this caveat in mind, we should look at students, classrooms, instructional strategies and ourselves as educators in light of what is now known about cognitive or learning styles.

Although various researchers and authors have developed terminology and models for working with learning styles (see "Resources for Intervention"), the common message is clear: just as adults have certain preferred conditions under which they do their optimal learning, so do children.

Researchers (Dunn and Dunn, 1979) are finding that teachers tend to teach in the same style in which they prefer to learn, and that not all children can easily accommodate themselves to learn well in a teacher's preferred style. Consequently in many classrooms there is a serious discrepancy between what is being taught and what is being learned, especially by minority children.

The way children (and adults) prefer to receive and process new information (learning style) is initially influenced by the culture into which they are born. Most of our school curricular and evaluation materials, as well as instructional methodologies, have been developed from the perspective of educators who manifest certain learning styles common to their own class and/or culture. In fact, one research team (Ramirez et al., 1974) suggests that teachers tend to give higher evaluations to students with the same learning style preference as themselves.

There is a growing demand that instructional programs include strategies which address the needs of various learning styles. Some educational researchers (Witkin, Moore, Goodenough and Cox, 1977) concur with the minority parents who have raised the issue of the relationship between classroom structure and student achievement. Evidence indicates that some of the unstructured, open-ended or highly competitive approaches to learning may have actually inhibited academic achievement in many minority children because these strategies were incompatible with the way many people from those cultures initially approach learning.

Some children may have had a cultural orientation that views the environment as unified, with order being inherent; it is inappropriate for the individual to deal with fragments or impose order. Maestas (1977), in discussing cultural attitudes which may inhibit participation in science, mentioned the conviction held by many Mexican and Native Americans that human beings should not attempt to manipulate nature. Order is assumed and there is nothing one can or should do about changing it. Unfortunately, economic, social and political realities only serve to reinforce this reliance on an external locus of control (discussed earlier under "Persistence").

It follows that the children may expect all aspects of their learning to be ordered by an external source (the teacher or textbook, most likely). The adjustment to the constant responsibility of imposing order may be difficult and time-consuming unless effective transitional strategies are developed and implemented. Without structured intervention, such cultural values may translate into a sense of helplessness, dependency and unproductivity in a classroom where children are expected to decide which assignments to do first, how to proceed and how to rearrange the instructional materials or environment to best fit the task.

Baldwin, Gear and Lucito (1978) developed a list of the eight most common descriptors for children who are affected by cultural diversity or economic deprivation:

1. outer locus of control rather than inner locus of control
2. loyalty to peer group
3. physical resiliency to hardships encountered in the environment
4. language rich in imagery and humor rich with symbolism; persuasive language
5. logical reasoning; planning ability and pragmatic problem-solving ability
6. creative ability
7. social intelligence and feelings of responsibility for the community; rebellious regarding inequities
8. sensitivity and alertness to movement

Each of the descriptors has a probable environmental or cultural origin and each impacts on the child's classroom experience. For example, an outer locus of control requires guidance

and supervision for task completion; loyalty to peer group explains the success of team or cooperative activities.

Hilliard (1976), in revising the pre-screening instrument used by the San Francisco Unified School District to identify gifted elementary minority students, described significant behaviors of Black children which correlate to items on the original checklist. (The original instrument was based on the work of Paul Torrance.) These behaviors include: being hard to con, knowing what he or she wants to do, being good at guessing and making quick decisions. These particular behaviors require logical reasoning and pragmatic problem solving skills. Such talents facilitate success in out-of-school activities, but may be viewed as obstinacy in the school and rejected in the formal environment of a classroom. However, a closer examination of what the child is communicating often yields insight into a coherent system of thought, consistent with the values of his or her culture, and should be viewed as a positive attribute. Instructional practices should promote the transfer of these types of thinking skills to classroom tasks. This child needs exposure to systematically developed strategies for solving academic problems. Science and mathematics are especially appropriate systems which can be explored logically with objectivity.

To establish an environment of successful participation, teachers should recognize and plan for learning style differences in the classroom. Additionally, children need experiences which help them to gradually learn how to function successfully in situations which do not compliment their basic learning style preferences.

Classroom Factors

• Teacher Expectations

Teacher expectations and perceptions may have a significant effect on minority student performance in both mathematics and science as evidenced by these research-based observations:

Rist (1970)—The perceptions teachers have about students are determined by social and cultural criteria, not academic criteria.

Dusek (1975)—Teachers frequently assume students to be less capable of learning if they are Black or poor. This leads to differential treatment which affects student achievement.

Jackson and Cosca (1974)—White students receive significantly more praise and encouragement than Hispanic students.

Rowe (1974)—Top-rated students are allowed more time to answer questions and participate in a differentiated verbal reward system.

Gay (1975)—Teacher's behavior toward students and the opportunities available to students are primarily based on the teachers' perceptions and expectations.

Teachers tend to treat Black and white students differently: white pupils receive more praise and other positive reinforcement than Black students.

These and other researchers have designed systems for observing and instruments for recording teacher-student interaction patterns in the classroom. Evidence is mounting to indicate that our perceptions about students influence our expectations of what they can achieve and how they will behave. These expectations can become self-fulfilling prophecies.

Positive teacher expectations improve student behavior and increase achievement. When teachers are told, for example that randomly selected students are high achievers, or that these students have been identified as "intellectual bloomers" who are expected to make high academic grades, teacher behavior varies enough to have significantly positive effects on student performance, both in the classroom and on I.Q. tests (Rosenthal and Jacobson, 1968; Good and Brophy, 1970; Bloom, 1981; Good, 1981).

Research indicates that teachers tend to see minority students as lower achievers and majority students as higher achievers even when performance is identical (Woodworth and Salzer, 1971; Antonopolis, 1972; Crowl, 1971). In one study of undergraduate student-teachers' interaction with a sample of 264 Black and white seventh- and eighth-graders, it was found that Black youngsters were given less attention, ignored more, praised less, and criticized more than their white counterparts (Rubovits and Maehr, 1973). Washington (1982), in a study of racial differences in teacher perceptions of first and fourth grade students reported that both Black and white teachers viewed Black boys as most negative and Black girls next on traits such as achievement, cooperation, adjustment and physical appearance. Regardless of gender, Black children were viewed more unfavorably than white children by both Black and white teachers. Gay (1975) hypothesized that teachers tend to react to students through their own middle class standards and perceptions. She also theorized that more pupils from racial minorities fall into the low socio-economic groups and are labeled as troublemakers and low achievers.

Mathematics and science are often perceived as higher-order disciplines and teachers often perceive minorities as low-achievers. It seems likely that mathematics and science may be perceived by many elementary teachers as a white-male domain and therefore the most positive expectations in those disciplines are reserved for white males. The model developed by Good and Brophy (1978, p.72) presents us with a helpful summary of how expectations affect student behavior:

1. The teacher expects specific behavior and achievement from particular students.

2. Because of these different expectations, the teacher behaves differently toward different students.
3. This treatment communicates to students what behavior and achievement the teacher expects from them and affects their self-concept, achievement motivation and level of aspiration.
4. If this treatment is consistent over time, and if the students do not resist or change it in some way, it will shape their achievement and behavior. High-expectation students will be led to achieve at high levels, while the achievement of low-expectation students will decline.
5. With time, students' achievement and behavior will conform more and more closely to that originally expected of them.

• Teacher Anxiety: Mathematics

Elementary mathematics instruction may be significantly affected by mathematics anxiety experienced by some teachers. The mathematical competency of the teacher is a factor that has not been well researched, particularly at the elementary and middle school levels. A logical argument can be made that teachers who are not well-trained in mathematics and especially those who have some anxiety or negative feelings about mathematics are inadequate math teachers and poor models for developing mathematical competency and interest. Some have been observed teaching only those curriculum concepts they feel comfortable with, avoiding concepts they find stressful. Math anxious teachers can pass their fears to students who have previously felt an intuitive appreciation for mathematics.

The issue of gender must be raised in any discussion of teachers, math anxiety and minority achievement. Since 87% of the teachers at the elementary school level are female and math anxiety has been prominent among females, many elementary school teachers may be providing both poor instruction and poor role models. It may be reasonably argued that while these teachers will avoid or provide ineffective instruction in areas where they do not feel competent, their higher expectations for white male students may somewhat compensate for the deficient instruction. Thus inadequate instruction may disproportionately affect the minority student, the low socio-economic student and the female student.

Pulos, Stage and Karplus (1982) conducted a study of the relationship between school setting and student mathematics reasoning skills in three similar schools with sizable minority populations. They found that student attitudes toward mathematics and performance on reasoning tasks were highest in the school with the most positive teacher attitudes toward students and mathematics instruction. In that school:

a. The teachers believed that a large percentage of their students were motivated to perform well in mathematics.
b. The teachers felt comfortable with the mathematics curriculum and freely supplemented the texts with materials which challenged students to think.
c. The teachers participated in regular in-service programs on the teaching of problem solving skills.
d. The teachers effectively applied the in-service program strategies in their classrooms.

• Teacher Anxiety: Science

Although the issue of science anxiety has not received the level of public attention given to math anxiety, Mechling and Oliver (1983) have summed up the situation bluntly. In *Handbook II* of the Project for Promoting Science Among Elementary School Principals, these authors point out that "Many teachers slough off their science teaching responsibilities. Teachers who are effective in other areas often avoid science because they lack training and have no confidence in their ability to teach it, or because they don't like science..." (p. 20). Sometimes this avoidance is excused with "I don't have time to teach science because of the pressures to get the basics taught." Later in *Handbook IV* they assert that teachers' attitudes toward science and the way it is taught most likely determine children's attitudes toward science. A teacher with science anxiety only reinforces the misperceptions of the minority child who may come from a culture in which science is perceived with distrust, and the methodology

and knowledge of science are considered incomprehensible.

Thus, most of the preceding discussion of math anxiety in teachers and its impact on minority students can be appropriately applied to science instruction as well. There is one significant difference which must be kept in mind: improved mathematics instruction and achievement are integral components of the "back to basics" movement while the importance of excellent science instruction has been largely neglected in this crusade. Because of the attention paid to building basic skills in mathematics, the test scores in this area of mathematics are improving for many minority students while their performance in science skills reflects no similar substantial gains.

Elementary school teacher effectiveness in mathematics and science may be suffering from a double-edged sword: the anxiety-avoidance syndrome of teachers and the behavior pattern of teachers based upon biased perceptions and low expectations for minority students.

• Instructional Practices

The preceding discussion explored student and teacher related factors which appear to affect minority student participation and performance in mathematics and science. Examination of these factors forces us to look at the relationship between minority student achievement, instructional strategies and programs.

While there is no absolute agreement on which instructional practices have contributed most to minority student underachievement, the following list represents some of the long time practices frequently mentioned:

a) Ineffective practices common to both mathematics and science teaching

1) utilizing teaching strategies which do not consider a variety of learning style needs

2) overemphasizing drill and memorization of facts and underemphasizing understanding and application of concepts to the student's environment

3) promoting a highly competitive rather than a cooperative environment for students

4) teaching mathematics and science in isolation from each other, and in isolation from the rest of the curriculum

5) waiting an insufficient period of time (less than 3 seconds) for a student's response to a teacher's questions

6) neglecting to incorporate manipulative materials and hands-on activities as regular instructional strategies

7) utilizing textbooks, audiovisuals and other materials which communicate race bias and/or which do not represent the multicultural realities of the student's environment

b) Ineffective practices in mathematics teaching

1. teaching as though mathematics has no relationship to the child's real world; using irrelevant word problems and unfamiliar analogies and examples
2. presenting mathematics as a pencil and paper activity neglecting the tactile or kinesthetic-based learning needs of children
3. promoting the belief that mathematics is logical but not creative, and that there is one best way to do a problem
4. disregarding the need for systematic instruction in "how to solve problems"

c) Ineffective practices in science teaching

1. focusing exclusively on science content, giving little emphasis to the process of science which develops transferable thinking skills
2. teaching from the textbook or by "teacher talk" most of the time
3. providing too few hands-on experiences which facilitate student understanding of abstract science concepts
4. allotting insufficient time for science lessons
5. neglecting to promote science as a problem-solving discipline, suitable for exploring out of school conditions and natural phenomena

Summary and Implications

Student and Teacher Related Factors Influencing Minority Student Participation and Performance

FACTORS	IMPLICATIONS FOR INTERVENTION

STUDENTS: AFFECTIVE FACTORS

ATTITUDES

Minority students have positive attitudes toward mathematics and science in the early grades.

1. To maintain these attitudes, students must continually be involved in challenging, "hands-on" activities related to their real world. (See Educational Programs.)*
2. They must see others, from a cultural background like theirs, who have maintained this interest in science and mathematics. (See Career Motivation and Professional Organizations.)*

PERSISTENCE

Those who are most successful in mathematics and science have developed the ability to persist. Having the ability to persist in the face of conflict is essentially related to a positive self-concept.

3. To develop this quality, children must be encouraged through the teacher's feedback and guidance to persevere as they work their way through appropriately challenging problems and situations.
4. They must make decisions, experience success, receive praise and constructive criticism, and recognize the relationship between their decisions, their actions and their success.
5. Teachers may require training in identifying the key elements of persistence and in designing strategies to develop them in children.

STEREOTYPING

Many teachers, majority and minority, as well as many minority students, tend to stereotype mathematics and science as white male domains.

6. Teachers should introduce male and female minority persons with mathematics and science-related careers. These role models can counteract race and sex stereotyping. (See Career Motivation and Professional Organizations.)*
7. The historical and contemporary accomplishments of minorities in mathematics and science must be systematically included in the curriculum. (See Career Motivation.)*
8. Students and teachers must become alert to the presence of race and sex stereotyping in instructional and advertising materials. (See Bias in Instructional Materials.)*
9. Multiethnic television programs developed to provide children with information about science concepts and careers should be used in the classroom and at home to counteract stereotyped images. (See Career Motivation.)*

*Appropriate resources are listed in Section VI, "Resources for Intervention," under the topical heading indicated by the ( ).

FACTORS	IMPLICATIONS FOR INTERVENTION
UTILITY	
Minority students are less likely to understand how the study of mathematics and science is applicable to everyday life, and valuable to their future schooling and jobs.	10. Good counseling by teachers and guidance counselors can provide a realistic picture of the relationship between students' present actions and future course and career options. 11. Exposure to persons who use mathematics and science in the workplace expands minority students' awareness of the usefulness of these disciplines. 12. Science and mathematics should be taught in an interdisciplinary manner, enabling students to experience mathematics as an essential tool of science. (See Educational Programs.)* 13. Minority students must have many regular opportunities to use computers for more than drill and practice and computer-assisted instruction. Access to computer technology for creative activities increases motivation and awareness of useful applications of mathematics and science. 14. The curriculum should focus on problems, investigations, discussions, trips, and activities designed to integrate mathematics and science skills into the everyday experiences of the students.
INFLUENCE OF SIGNIFICANT OTHERS	
Teachers, counselors, parents and peers have a role in shaping students' attitudes toward mathematics and science.	15. Encouraging minority students to take the more challenging educational path conveys a message of confidence in their abilities. 16. Positive, substantive interactions which communicate high expectations can become a self-fulfilling prophecy. 17. Interactions with successful older minority students, teamwork, peer tutoring and cooperative learning strategies are effective ways to positively utilize peer influence. (See Educational Programs.)* 18. Parent education programs help parents become aware of the importance of mathematics to their children's futures. Such programs should offer suggestions and activities for parents to use in nurturing children's interest in mathematics and science.

*Appropriate resources are listed in Section VI, "Resources for Intervention," under the topical heading indicated by the ( ).

FACTORS	IMPLICATIONS FOR INTERVENTION

STUDENTS: COGNITIVE FACTORS

PREVIOUS EXPERIENCES

Minority students tend to perform best when the content is related to their previous experiences.	19. Mathematics and science instruction must provide out-of-school experiences to make up for experiential deficits. The school curriculum should include field trips to zoos, museums, laboratories, ponds, streams, vacant lots, farms, generating plants, planetariums, aquariums, various worksites, hospitals, college campuses, etc. 20. Instruction in the classroom must be designed to include the kinds of enrichment experiences which contribute to knowledge, build self-confidence and develop thinking skills.

ACADEMIC DEFICIENCIES

Achievement test performances by minority students indicate growing competency in basic skills, but weakness in understanding and application of concepts.	21. Instructional programs which teach strategies for attacking and solving word problems in mathematics must be a curriculum component at each grade level. (See Educational Programs.)* 22. All instructional activities must be systematically organized with clear objectives. 23. Student progress in mathematics and science must be monitored daily. 24. Activity-based science programs, when implemented with sufficient teacher training and support, significantly improve minority student performance in science process skills, science content, mathematics and language development. (See Educational Programs.)* 25. Math labs with manipulatives and high-interest computer software can be used to develop competency in application of concepts. 26. Student teamwork and cooperative learning strategies improve motivation and achievement. (See Educational Programs.)*

LANGUAGE

Language minority students are handicapped in English-speaking mathematics and science classrooms and on achievement tests.	27. Teaching mathematics as a component of bilingual programs can improve the achievement of Spanish-speaking children. 28. Activity-based programs in mathematics and science with built-in linguistic objectives can increase language proficiency. 29. Direct instruction in word problem solving should emphasize tools for decoding the words and phrases. (See Language.)*

*Appropriate resources are listed in Section VI, "Resources for Intervention," under the topical heading indicated by the ( ).

FACTORS	IMPLICATIONS FOR INTERVENTION
MISUSE OF TESTING AND TEST DATA	
The use of standardized test data to predict achievement and to assess ability is detrimental to minority students.	30. Tests should be used to determine a child's actual progress rather than his/her disability. 31. Teachers should receive training on the proper use of test data and the purpose of diagnostic, criterion-referenced, norm-referenced and pre- and post-tests. 32. Student performance on tests must be analyzed and errors examined to identify specific skill and concept deficiencies. 33. There must be flexibility in grouping. An analysis of errors on practice assignments and tests can be the basis on which flexible groups are formed. Activity-based science and mathematics programs also provide opportunities for flexible, heterogeneous grouping. 34. Tests should be culturally fair and should assess the skills and content actually taught. 35. The teaching of test taking skills should be integrated throughout the ongoing curriculum.
LEARNING STYLES	
Instructional strategies frequently do not complement the learning styles of many minority students.	36. Through observations and/or diagnostic assessments, the learning style preferences of students can be determined. (See Learning Styles.)* 37. Concept and skill mastery activities should include: manipulatives, experiments, listening, reading, discussion, audiovisuals, movement, practical experiences, group and individual work, contracts, learning centers, writing, role playing, simulations, interviewing, and computers for problem solving. 38. Teachers should receive training on teaching styles and learning styles followed by instructional support for developing and implementing alternative instructional strategies like those cited above.

*Appropriate resources are listed in Section VI, "Resources for Intervention," under the topical heading indicated by the ( ).

FACTORS	IMPLICATIONS FOR INTERVENTION

CLASSROOM FACTORS

TEACHER EXPECTATIONS

Educators often perceive minorities as having inferior ability. This perception translates into an expectation of low achievement which is communicated to and internalized by the minority child.

39. Honest self-assessment by educators is the first step in breaking this cycle. (See Teacher Expectations.)* Questions like these must be asked:

    a. Who are my low achievers? (Is there an overrepresentation of minority students in this group?)

    b. How do I relate to minorities and low achievers?

    c. Do I:
    - Interact more with high achievers and ignore and interrupt low achievers more frequently?
    - Ask more and higher level questions of high achievers and provide low achievers with questions that require only simple recall?
    - Follow up with probing questions for high achievers and call on someone else if a low achiever is unable to provide a prompt, accurate response?
    - Provide a longer wait time for high achievers to respond to a question and cut off response time for low achievers who hesitate?
    - Seat high achievers closer to the teacher's usual position and cluster low achievers further away?
    - Praise high achievers more often and criticize low achievers more frequently?
    - Provide supportive communications for high achievers and engage in dominating behaviors with low achievers?
    - Provide high achievers with detailed feedback and give less frequent, less accurate and less precise feedback to low achievers?
    - Demand more work and effort from high achievers and accept less from low achievers?

40. Once a staff is aware of the ways in which expectations are communicated to students, teachers can observe one another's interaction with identified low achievers and minority students. Individual teachers can then design plans for changing their own behavior in the classroom. (See Teacher Expectations.)*

*Appropriate resources are listed in Section VI, "Resources for Intervention," under the topical heading indicated by the ( ).

FACTORS	IMPLICATIONS FOR INTERVENTION
TEACHER ANXIETY: MATHEMATICS	
Teachers who do not have positive attitudes about mathematics are likely to provide inadequate instruction; additionally, they are poor models for mathematical competency and interest.	41. A staff assessment of attitudes toward mathematics will (1) identify teachers experiencing mathematics anxiety or avoidance and (2) provide an opportunity for teachers to openly discuss the problem. 42. Math-anxious teachers can form a group for discussion and activities designed to change attitudes. (See Teacher Anxiety in Mathematics and Science.)* 43. Effective inservice programs, tailored to the mathematics needs of the local school, can provide teachers with new understandings of content and teaching strategies.
TEACHER ANXIETY: SCIENCE	
Many elementary teachers avoid teaching science because they lack training in science content and science teaching methods, and they have no confidence in their ability to teach it.	44. Confidence and competency can be increased through regular participation in science inservice workshops which offer specific skills, techniques and materials. 45. There must be ongoing opportunities to try out new science activities before using them in the classroom. Time should be provided at workshops, faculty meetings or during prearranged preparation time. 46. Professional journals and other materials which focus on elementary school science often combine content and suggested strategies. (See Teacher Anxiety in Mathematics and Science.)* 47. The development of a supportive network which includes several science teachers from the middle or junior high schools and local college faculty should be established.
INSTRUCTIONAL PRACTICES	
A number of instructional practices have been associated with low achievement in minority students.	*See all of the above* for appropriate alternatives.

*Appropriate resources are listed in Section VI, "Resources for Intervention," under the topical heading indicated by the ( ).

IV
Intervention Strategies and Programs

A Positive Classroom Climate

Your students are likely to experience five major career changes as twenty-first century adults in a technological world. Maximum competency in mathematics, science and communication skills are essential for minority students if they are to have opportunities for full participation in our rapidly changing marketplace. Students and parents must understand that algebra and geometry skills are required for the college and non-college bound and trigonometry or pre-calculus is essential for the college bound. A strong mathematics background is needed for hundreds of professional, technical and vocational jobs, as well as for military entrance exams, civil service exams and various placement tests. Minority children must leave elementary school feeling that it is only natural that they continue their studies of mathematics and science throughout secondary school.

To develop a positive feeling about their academic abilities, students need the nurturing environment of a positive school and classroom climate. Although there are many variables influencing the climate in a classroom, it is important to summarize several which are particularly important in the mathematics or science classroom:

A. Teacher Expectations

A teacher's belief that every student has potential to learn is communicated when that teacher

- establishes common educational goals for all students
- holds all students accountable for the same standards of performance in classroom discussion
- gives all students equal time for participation in classroom discussion; makes specific efforts to engage those students that are less active in classroom discussion
- uses questioning techniques that promote curiosity and inquiry; addresses different levels and types of questions to students at all achievement levels
- increases wait time to a minimum of three seconds, especially if the student is being asked to reorganize facts, interpret information or form opinions
- waits a similar amount of time for responses from low and high achieving students
- probes, restates or simplifies questions for those who do not answer or answer incorrectly
- after stating a question, calls on specific students rather than on volunteers only; makes sure that all students are given equal opportunities to respond
- provides all students with immediate and objective feedback on their response; treats errors as an inevitable part of the process of learning but corrects them before they can be repeated
- praises correct thinking and responses from *all* children
- responds to requests for extra help

B. Learning Atmosphere

To create a classroom atmosphere that promotes the learning for all students, a teacher must make every effort to

- establish a task-oriented, relaxed environment
- emphasize cognitive achievement
- refrain from using more control-oriented behavior toward lower achievers than toward others
- enhance the self-esteem of each student; recognize and reward excellence

- foster the ability of each student to feel control of his/her own future by listening to the ideas of students and by providing opportunities for decision-making
- model academic behavior for the students by being well prepared for class and having materials ready to use
- plan initial whole-class instruction for each unit
- identify alternative strategies for reteaching the unit objective(s) to those students who have not mastered the skill
- identify enrichment/extension strategies for the unit objective(s)

C. Social Organization

Teachers and administrators should work together to establish a mixed-ability, integrated learning environment in the classroom by

- monitoring the seating arrangement in the room to ensure that higher achievers are not always close to the teacher with the best view of the chalkboard
- making special efforts to achieve classroom integration when students self-segregate in seating arrangements or other forms of classroom organization
- assigning students to lines, seats, teams or groups so that they are not segregated on the basis of race or achievement level
- assigning tasks and responsibilities without regard to race, ethnic, and sex stereotypes
- using cooperative learning activities which promote achievement through mixed ability grouping

Intervention Programs

Beyond the classroom, there can be effective school-wide and system-wide programs designed to identify and nurture the mathematics and science talents of minority students. Many successful intervention programs have been initiated by a committed principal, teacher, parent, local college, local museum, professional/fraternal organization, scientist, mathematician or engineer. Many of these programs draw upon the combined efforts of all these resources. These programs have recognized the tremendous value of parent and community support in achieving the program goals. Consequently, most successful programs have built-in parent (and frequently community) involvement mechanisms.

To facilitate the process of developing an appropriate intervention program for a classroom, school or school district, the following list of strategies has been compiled from the research on practices which impact positively on minority student achievement. This information was extracted from the unpublished results of a 1983 study of exemplary K-12 precollege programs designed to facilitate increased female and minority student performance and participation in mathematics and science. (The study was conducted for the National Science Commission on Precollege Education in Mathematics, Science and Technology by the Office of Opportunities in Science, American Association for the Advancement of Science.)

A. Components of Successful Programs

Exemplary intervention programs in mathematics and science reflect the following characteristics:

- a clearly articulated objective, e.g., to encourage the target group to move into math/engineering/science based careers
- clearly articulated short-term and long-term goals
- the identification and implementation of specific intervention strategies
- institutionalized program strategies that assure the maintenance of increased levels of minority student participation and performance
- the support of school administrators who are committed to the program objective and frequently act as facilitators
- teachers who have high expectations for the achievement of all students
- teachers who are subject matter competent
- role models who are from the minority population groups
- guidance counselors who provide accurate college and career information for science, mathematics and engineering to all students
- a plan for involving parents

B. Successful Program Strategies

The most effective programs have been found to include strategies which:

- provide an integrated approach to the mathematics and science curricula (Teachers of both disciplines work cooperatively.)
- integrate mathematics and science curricula into other subject areas, e.g., have math and science provide the content for a communications component focusing on writing and speaking skills
- provide a sequential (K-12) curriculum which prevents "content/skill gaps," especially in mathematics
- develop peer support systems
- encourage students to work in teams, a technique which seems to be more compatible with the personal style of the targeted population
- emphasize utility and practical applications of science and mathematics as opposed to heavy reliance on theory
- focus on higher level cognitive skills related to problem solving, understanding and applications
- focus on enrichment activities, emphasizing the scientific process over the simple accumulation of knowledge
- provide a "hands on," laboratory-activity orientation
- focus on real life problems which incorporate the interests and concerns of the targeted group

C. Effective Utilization of Community Resources

Strategies that have been successful in harnessing community resources to improve minority participation in math and science programs include:

- cooperative ventures between schools and local colleges and universities. Programs in science/mathematics/technology for minority precollege students are often organized as summer programs or Saturday programs for enrichment.
- established links with business and industry. Many programs have been established as a result of a cooperative relationship between schools and industry. Support of the business sector has often resulted in contributed funds and the distribution of free materials as well as provision of scientific and engineering personnel to serve as role models.
- use of professional organizations for career motivational materials and role models

D. Examples of Intervention Programs*

The following programs were designed to increase the participation and achievement of elementary minority students in mathematics and science, and were among more than two hundred projects that participated in a 1983 assessment of precollege intervention programs. (The actual name of the project is in bold italics.)

Resource Center for Science and Engineering: Saturday Academy, Teacher Training, Counselor Training
Community Outreach Program
Atlanta University
223 Chestnut Street, S.W.
Atlanta, GA 30314
(404) 681-0251, extension 320
contact person: Dr. Melvin Webb

LESSON—Lawrence Livermore Elementary School Study of Nature
(Grades 5–8)
Lawrence Livermore National Laboratory
P.O. Box 808, L-416
Livermore, CA 94550
(415) 423-2794
contact person: William Raymond

Minority Participation in the Earth Sciences Teacher Workshop
(Grades 1-6)
Minority Participation in the Earth Sciences
345 Middlefield Road, MS44
Menlo Park, CA 94025
(415) 323-8111, extension 2713
contact person: Dr. Joyce Blueford

*For information about additionally strategies and programs see Section VI, "Resources for Intervention," pp. 36–46.

Interest and Involvement in Science Program (Grades 3-6)
U.S. Naval Academy
Department of Chemistry
Annapolis, MD 20772
(301) 267-3405
contact person: Dr. Edward D. Walton

Saturday Science Academy (Grades 4-6)
Southwest Resource Center for Science and Engineering
Department of Mathematics
University of New Mexico
Albuquerque, NM 87131
(505) 277-3641 or 4613

Mathematics Project for Teachers of Native Americans
Mathematics Learning Center
P.O. Box 3364
Salem, OR 97302
(503) 370-8130
contact person: Dr. Eugene Maier

EQUALS (Grades K-12)
Lawrence Hall of Science
University of California
Berkeley, California 94720
(415) 642-1823
contact person: Nancy Kreinberg

Science Teachers Workshop
Washington Metropolitan Area Network of Minority Women in Science, Inc.
P.O. Box 28440
Washington, D.C. 20005
(202) 727-2212
contact person: Dr. Marion Johnson-Thompson

Satellite Summer Enrichment Program for Gifted/Talented Students (Grades 2-11)
Satellite Saturday Enrichment Program
School of Education
Howard University
2441 4th Street, N.W.
Washington, D.C. 20059
(202) 636-5633
contact person: Dr. James H. Williams

V
Getting Started: Tools for Assessment and Planning

A Leader's Model For Planning Equity Intervention Programs

While this model was originally developed by Ross Taylor (for the National Council of Teachers of Mathematics) for planning equity programs in mathematics, it can be equally as useful in planning equity intervention programs in science or in a combined mathematics/science program.

1. State goals
   a. Increased participation and achievement for students
   b. Increased awareness for staff
   c. Increased involvement by parents and community
2. Assess the status quo
   a. Collect information on participation and achievement
   b. Collect information on attitudes
3. Seek information
   a. What programs have been successful?
   b. What resources are available? (in the school, school system, business community, college community, county or state)
4. Develop the plan
   a. State objectives
   b. Define tasks
   c. Develop timetable
   d. Assign responsibilities
5. Implement the plan
   Give consideration to the following
   a. Awareness of equity issues
   b. Career information
   c. Equity compensatory programs
   d. Pluralistic learning materials
   e. Staff development
   f. Parent involvement
6. Evaluate
   a. Evaluate the specific goals and objectives
   b. Use assessment information as baseline data
   c. Use evaluation information to refine and improve the program
   d. Publicize successes

NOTE: Assessment activities should include reviewing and comparing mathematics and science achievement test scores for minority and majority students in the school. Data collection forms have been included to facilitate the assessment process. A conference with the secondary school principal, guidance counselors, and/or chairpersons of the mathematics and science departments may facilitate the collection of follow-up data on the enrollment and performance of an elementary school's former students in secondary mathematics and science courses.

Adapted from H. Cheek (ed.), *Handbook for Conducting Equity Activities in Mathematics Education* (Reston, Va.: National Council of Teachers of Mathematics, 1984).

Checklist for Equity in Mathematics and Science

Developed by the Mid-Atlantic Center for Race Equity
The American University

(This instrument was inspired by G. Fauth and J. Jacobs, "Equity in Mathematics: The Educational Leader's Role," *Educational Leadership* 36 (March 1980): 485–490.)

	MATHEMATICS			SCIENCE		
	Yes	No	N/A*	Yes	No	N/A*
A. Starting Out						
1. Have you compared the achievement test data for your minority and majority students?	☐	☐	☐	☐	☐	☐
2. Do you have goals which target equity in minority student participation and performance in mathematics and science?	☐	☐	☐	☐	☐	☐
3. Have you developed a network with other administrators in your district or region who share your goals for minority students?	☐	☐	☐	☐	☐	☐
4. Do you have an intervention plan for achieving and maintaining your equity goals?	☐	☐	☐	☐	☐	☐
5. Have you involved your teachers and minority parents in the development and implementation of the intervention plan?	☐	☐	☐	☐	☐	☐
B. Building Student Support and Positive Self-Concept						
6. Do you have a system for the early identification of minority students with high exceptional ability and/or interest in mathematics or science?	☐	☐	☐	☐	☐	☐
7. Have you developed an effective peer support program for minority students with exceptional ability and/or interest? (a club, group projects, a special regrouping arrangement, etc.)	☐	☐	☐	☐	☐	☐
8. Does your school provide career education programs which make all students, parents and teachers aware of the importance of studying a minimum of three years of mathematics and science in high school?	☐	☐	☐	☐	☐	☐
9. Does your school provide programs and materials to help primary school parents and teachers capitalize on the natural interest and positive attitudes minority youngsters have for mathematics and science?	☐	☐	☐	☐	☐	☐

*N/A = not applicable

	MATHEMATICS			SCIENCE		
	Yes	No	N/A*	Yes	No	N/A*
10. Do you provide minority role models who are enrolled in school programs or work in careers related to mathematics, science or technology and who demonstrate a high interest in helping minority youngsters?	☐	☐	☐	☐	☐	☐
11. Do the children have frequent opportunities to interact with the minority role models?	☐	☐	☐	☐	☐	☐
C. Instruction						
12. Do your mathematics and science programs include effective strategies to address specific academic deficiencies?	☐	☐	☐	☐	☐	☐
13. Does your mathematics program regularly include manipulatives to facilitate the understanding of concepts?	☐	☐	☐	☐	☐	☐
14. Is the science program activity based and student centered, emphasizing the development of science content and process skills?	☐	☐	☐	☐	☐	☐
15. Does your school assume responsibility for providing regular opportunities for minority students to master computer concepts?	☐	☐	☐	☐	☐	☐
16. Do you monitor the mathematics and science instructional materials for racism and sexism?	☐	☐	☐	☐	☐	☐
17. Do teachers examine the content of their instructional materials (narratives, pictures, analogies, examples, problems) to detemrine if there is a bias toward white males?	☐	☐	☐	☐	☐	☐
18. Do you provide instruction for teachers in how to handle bias in instructional materials?	☐	☐	☐	☐	☐	☐
19. Are the historical and contemporary contributions of minorities in mathematics, science and technology woven into the curriculum?	☐	☐	☐	☐	☐	☐
D. Developing and Training Staff						
20. Do you hire and support minority teachers, especially those with a real or potential affinity for mathematics and science?	☐	☐	☐	☐	☐	☐
21. Do you encourage the development of leadership potential in minority teachers? (Minority students need to see other minority persons who are successful participants in the school environment.)	☐	☐	☐	☐	☐	☐

*N/A = not applicable

	MATHEMATICS			SCIENCE		
	Yes	No	N/A*	Yes	No	N/A*
22. Have you identified and assisted those teachers who are "math or science anxious?"	☐	☐	☐	☐	☐	☐
23. Have you considered "exchange teaching?" (One solution to the mathematics/science anxiety problem is to have those teachers who enjoy mathematics and science do all of the instruction in those disciplines.)	☐	☐	☐	☐	☐	☐
24. Do you provide and participate in ongoing staff development programs which focus on techniques for making mathematics more interesting?	☐	☐	☐	☐	☐	☐
25. Do you provide and participate in "hands on" workshops which prepare teachers for an activity-based science curriculum?	☐	☐	☐	☐	☐	☐
26. Do you provide staff development programs on teacher expectations and their role in minority student achievement?	☐	☐	☐	☐	☐	☐
27. Have you and your staff participated in inservice education programs on cognitive or learning styles?	☐	☐	☐	☐	☐	☐
28. Has your staff used diagnostic instruments which provide information about students' learning styles?	☐	☐	☐	☐	☐	☐

E. Evaluating Your Equity Plan

29. Do you continuously monitor minority student achievement and participation in classrooms and extracurricular mathematics/science activities?	☐	☐	☐	☐	☐	☐
30. Are the minority students actively participating in classroom discussions, experiments and projects?	☐	☐	☐	☐	☐	☐
31. Has there been an increase in minority student participation in science fairs and clubs?	☐	☐	☐	☐	☐	☐
32. Do bulletin boards, book reports and library activities regularly reflect minority involvement in mathematics and science (or technology)?	☐	☐	☐	☐	☐	☐
33. As a result of your school's intervention plan are more minority students becoming high achievers by the time they leave your school?	☐	☐	☐	☐	☐	☐
34. Are more minority students enrolling in advanced mathematics and science classes after entering secondary school?	☐	☐	☐	☐	☐	☐

*N/A = not applicable

Data Collection Form #1

Elementary School
Mathematics Achievement Test Data

Directions:
Please fill in achievement test score data by sex, race, ethnic group and grade for your school.
Feel free to modify the headings in the chart so as to make them appropriate for reporting your school's data.

GRADE LEVEL	MEAN SCORE FOR ALL STUDENTS IN THAT GRADE	WHITE STUDENTS		BLACK STUDENTS		HISPANIC STUDENTS		NATIVE AMERICAN STUDENTS		ASIAN STUDENTS		OTHER	
		M	F	M	F	M	F	M	F	M	F	M	F
1													
2													
3													
4													
5													
6													
7													
8													

Name of school _____

Total School Population Data:

	Total # Students	White		Black		Hispanic		Native American		Asian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%
Male													
Female													

Prepared by the Mid-Atlantic Center For Race Equity, The American University

Data Collection Form #2

Elementary School
Science Achievement Test Data

Directions:
Please fill in achievement test score data by sex, race, ethnic group and grade for your school.
Feel free to modify the headings in the chart so as to make them appropriate for reporting your school's data.

GRADE LEVEL	MEAN SCORE FOR ALL STUDENTS IN THAT GRADE	WHITE STUDENTS		BLACK STUDENTS		HISPANIC STUDENTS		NATIVE AMERICAN STUDENTS		ASIAN STUDENTS		OTHER	
		M	F	M	F	M	F	M	F	M	F	M	F
1													
2													
3													
4													
5													
6													
7													
8													

Name of school _____

Total School Population Data:

	Total # Students	White		Black		Hispanic		Native American		Asian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%
Male													
Female													

Prepared by the Mid-Atlantic Center For Race Equity, The American University

Data Collection Form #3

Secondary School

Mathematics/Science Enrollment Data

This survey is appropriate for secondary schools in which optional math and science courses are offered.

Directions:

Examine enrollments in the specified math and science courses. Report numbers and percents by ethnic groups, race and sex of student.

COURSE		TOTAL		WHITE		BLACK		HISPANIC		NATIVE AMERICAN		ASIAN		OTHER	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
GENERAL MATH (basic skills, consumer math, business math)	Male														
	Female														
	Total														
ALGEBRA I (1st year algebra even if given in more than two semesters)	Male														
	Female														
	Total														
GEOMETRY	Male														
	Female														
	Total														
ALGEBRA II (second year algebra with or without trigonometry)	Male														
	Female														
	Total														
TRIGONOMETRY (analytic geometry, pre-calculus & other advanced math)	Male														
	Female														
	Total														
CALCULUS	Male														
	Female														
	Total														
COMPUTER SCIENCE	Male														
	Female														
	Total														
CHEMISTRY	Male														
	Female														
	Total														
PHYSICS	Male														
	Female														
	Total														
ADVANCED PLACEMENT SCIENCE COURSES	Male														
	Female														
	Total														

Name of school _____

Grades represented in this school _____

Total School Population Data:

	Total # Students	White		Black		Hispanic		Native American		Asian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%
Male													
Female													

This form was adapted by the Mid-Atlantic Center for Race Equity, The American University, from A. Kaseberg, N. Kreinberg, and D. Downie, *Use EQUALS to Promote the Participation of Women in Mathematics* (Berkeley, CA: Lawrence Hall of Science, University of California, 1980), p.59.

VI
Resources for Intervention
Educational Programs
Science Intervention

Title	Source of Additional Information
SAPA II ***Science—A Process Approach*** An activity-oriented curriculum. 105 modules structured around the various processes of science. Program includes: (1) instructional booklets for teachers (objectives, possible teaching sequences and activities, evaluation measures), (2) kit materials, and (3) storage units. A filmstrip orientation program is available for training teachers. Note: Although copyrighted in 1975, recent studies indicate that SAPA is highly effective in developing science process skills especially with disadvantaged students. This may be due to the fact that it appears to be highly structured and incorporates mathematics skills. (K–6)	Doris Hadary Department of Chemistry The American University 4400 Massachusetts Avenue, N.W. Washington, DC 20016 telephone (202) 885-1762 Delta Education (Distributor) P.O. Box M Nashua, NH 03061 telephone 1-(800) 258-1302
SCIS, SCIIS ***Science Curriculum Improvement Study II*** Ungraded, sequential physical and life science programs. Developed and evaluated by Lawrence Hall of Science staff, originated by scientists, and adapted to elementary school children's needs. Challenging investigations using a laboratory approach. Kits, materials and teacher's guides. Note: Research studies indicate that SCIS tends to be more effective than other programs in the development of logic and science content. (K–6)	Herbert Their Lawrence Hall of Science University of California Berkeley, CA 94720 telephone (415) 642-8718 Delta Education (Distributor) P.O. Box M Nashua, NH 03061 telephone 1-(800) 258-1302
ESS ***Elementary Science Study*** A hands-on, "discovery" based approach. Children are able to explore the physical world directly. Fifty-six units on which a school science program can be built. (K–6)	Doris Hadary Department of Chemistry The American University 4400 Massachusetts Avenue, N.W. Washington, DC 20016 telephone (202) 885-1762 Delta Education (Distributor) see preceding entry
OBIS ***Outdoor Biology Instructional Strategies*** Many different activities requiring only a field, playground, pond, lawn, vacant lot, stream, sidewalk, school yard, etc. Includes activity cards, information for teachers and resource booklets. (5–9)	Dave Buller Lawrence Hall of Science University of California Berkeley, CA 94720 telephone (415) 642-8941 Delta Education (Distributor) see earlier entry

Title	Source of Additional Information
Laboratory Science and Art: A Mainstreaming Approach (book) by Doris Hadary A general discussion of the various activity-based science programs, highlighting their suitability for all students. Includes adaptations for mainstreaming children with handicapping conditions into these activities.	Doris Hadary Department of Chemistry The American University 4400 Massachusetts Avenue, N.W. Washington, DC 20016 telephone (202) 885-1762
3 . . . 2 . . . 1 Contact Public television series which uses adults and children to help children understand science concepts and relate them to everyday life (multiethnic). (Teacher's guide is available.)	Education Director Local public television station
Search for Solutions Set of nine films featuring scientists and technicians engaged in scientific investigations. Each film focuses on a particular aspect of problem solving (multiethnic). (Teacher's guide is available.)	Free on loan from Playback Associates 708 Third Avenue New York, NY 10017 telephone (212) 572-8570
Project for Promoting Science Among Elementary School Principals *Handbook I—Science Teaches Basic Skills* *Handbook II—The Principal's Role in Elementary School Science* *Handbook III—Characteristics of a Good Elementary Science Program* *Part A: Principal's Checklist of Characteristics* *Part B: Elaboration of the Principal's Checklist of Characteristics* *Handbook IV—What Research Says About Elementary School Science* by K. Mechling and D. Oliver, 1983	Publications National Science Teachers Association 1742 Connecticut Avenue, N.W. Washington, DC 20009 telephone (202) 328-5800

Mathematics Intervention

DMP ***Developing Mathematical Processes*** A program developed by the University of Wisconsin System Center for Cognitive Learning. Includes teacher's materials, students' materials and manipulatives. (K–6)	Delta Education P.O. Box M Nashua, NH 03061 telephone 1-(800) 258-1302
Problem Solving in Mathematics A co-basal program of problem-solving lessons and teaching techniques for grades 4–8 and 9 (algebra) developed by the Lane County (Oregon) Mathematics Project. Program includes 9 inservice audio cassette tapes available on loan.	Dale Seymour Publications P.O. Box 10888 Palo Alto, CA 94303-0879 telephone (800) 872-1100

Title	Source of Additional Information
Project SEED *(Special Elementary Education for the Disadvantaged)* The original program in which trained mathematicians worked with 4th and 5th graders helping them to discover and understand algebra concepts has been expanded to include primary and junior high grades covering several subjects.	William Johntz Project SEED 2336-A McKinley Avenue Berkeley, CA 94703
Math for Girls and Other Problem Solvers by D. Downie, T. Slesnick and J. Stenmark A book of enjoyable math challenges designed to build math self-confidence.	EQUALS Lawrence Hall of Science University of California Berkeley, CA 94720 telephone (415) 642-1823
SPACES (Solving Problems for Access to Careers in Engineering and Science) A book of exciting classroom activities for developing problem-solving skills, career awareness and mathematics affinity.	EQUALS Lawrence Hall of Science University of California Berkeley, CA 94720 telephone (415) 642-1823
Family Math A parent or teacher-led program which consists of a series of classes designed to make math fun for families. Resources include workshop materials and video tape.	EQUALS Lawrence Hall of Science University of California Berkeley, CA 94720 telephone (415) 642-1823
Handbook for Conducting Equity Activities in Mathematics Education Provides an overview of equity issues, discussion of several successful intervention programs, workshop materials, student activities and an extensive resource list.	National Council of Teachers of Mathematics 1906 Association Drive Reston, VA 22091 telephone (703) 620-9840
**** STAMM K–8—Systematic Teaching and Measuring Mathematics*** Designed to provide continuous progress in mathematics for all students. STAMM may be used in large and small group instruction, individualized instruction, math labs, etc.	Jefferson County Schools Lakewood, CO 80215 telephone (303) 231-2381
**** DPA: Diagnostic Prescriptive Arithmetic*** A basic arithmetic program in which concepts and problem-solving skills are developed and reinforced through experiences with manipulatives and real life situations. Suitable for large group, small group or individualized instruction.	Community School District #31 211 Daniel Low Terrace Staten Island, NY 10301 telephone (212) 447-3300, ext. 36,37

*These programs were selected from National Diffusion Network Division, *Educational Programs That Work: A Catalog of Exemplary Programs Approved by the Joint Dissemination Review Panel* (Washington, D.C.: U.S. Department of Education, 1983).

Some of these programs may no longer be funded for dissemination purposes. Therefore, for further information or assistance in selecting and implementing programs marked with an asterisk, contact your state facilitator for the National Diffusion Network:

District of Columbia (202) 282-0056; Maryland (301) 934-2992; Virginia (703) 536-5932 or (804) 732-3584; West Virginia (304) 636-6918

For a complete list of programs and state facilitators contact: National Diffusion Network Division, U.S. Department of Education, 1200 19th Street, N.W., Room 714F, Washington, DC 20036, (202) 653-7000.

Title	Source of Additional Information
CMSP—Comprehensive School Mathematics Program Designed for students of all ability levels, grades K–6, presenting problem solving and basic content as an extension of the child's own experiences. Effective in cognitive areas of relational thinking, estimation, large numbers, fractions, word problems. Stimulates math interest.	CMSP Demonstration Project 3120 59th Street St. Louis, MO 63139-1799 telephone (314) 781-2900, ext. 310
HOSTS Math: Help One Student To Succeed A diagnostic/prescriptive/tutorial mastery learning program flexible enough for K–6 classrooms and resource room use. (Computerized version also available.) Lesson plans emphasize the manipulative, representational approach to learning.	HOSTS Math 5802 MacArthur Boulevard Vancouver, WA 98661 telephone (206) 694-1705
TGT—Teams-Games-Tournament A cooperative learning model which deliberately places students in mixed ability teams for study, practice and peer motivation. Students are then temporarily grouped according to past performance into tournament groups in which games are used to assess their mastery of the content and they earn points to take back to their teams. Team scores and team recognition are essential elements. Improves academic performance and social relationships.	Center for Social Organization of Schools Johns Hopkins University 3505 North Charles Street Baltimore, MD 21218 telephone (301) 338-8249 or Mid-Atlantic Center for Race Equity The American University 5010 Wisconsin Avenue, N.W. #310 Washington, DC 20016 telephone (202) 885-8517

Cooperative Learning

TGT (see preceding entry)	
STAD—Student Teams-Achievement Divisions Employs the same team structure as TGT but uses quizzes instead of games and tournaments. After team practice and study, each student competes against his or her own prior performance on quizzes.	Same contacts as those listed for TGT
TAI—Team Assisted Instruction An approach to individualized mathematics instruction (grades 3–8) which incorporates students working in heterogeneous learning teams, a computerized diagnostic/placement test, team scores and team recognition, and regular cycles of individualized, small group and whole class instructional activities.	Center for Social Organization of Schools Johns Hopkins University 3505 North Charles Street Baltimore, MD 21218 telephone (301) 338-8249
Small-Group Teaching by S. Sharan and Y. Sharan, 1976 (book)	Educational Technology Publications Englewood Cliffs, NJ 07632

*See footnote on previous page.

Title	Source of Additional Information
Learning Together and Alone by D.W. Johnson and R.T. Johnson, 1975 (book)	Prentice-Hall, Inc. Englewood Cliffs, NJ 07632
Circles of Learning, Cooperation in the Classroom by D.W. Johnson, R.T. Johnson and P. Roy, 1984 (book)	Association for Supervision and Curriculum Development 225 N. Washington Street Alexandria, VA 22314 telephone (703) 549-9110

Thinking Skills

Instrumental Enrichment An intervention program designed by psychologist Reuven Feuerstein to develop thinking and learning skills and motivation.	Curriculum Development Associates, Inc. 1211 Connecticut Avenue, N.W. Suite 414 Washington, DC 20036 telephone (202) 293-1760

Career Motivation

The Science Careers Program A set of class activities, including filmstrip, tape and poster series; resource book for teachers—features many minority persons in science-related careers.	Research Triangle Institute P.O. Box 12194 Research Triangle Park, NC 27709
SPACES A six-part series produced for public television, designed to encourage minority children, aged nine to thirteen to prepare for science-related careers. Teacher's guide and video cassettes are now available on loan.	The Mid-Atlantic Center for Race Equity The American University 5010 Wisconsin Avenue, N.W. #310 Washington, DC 20016 telephone (202) 885-8517
COMETS—Science A set of 24 modules of science activities which introduce concepts designed to be reinforced by the visit of a science-related role model. Includes suggestions for finding appropriate role models. For grades 5–9.	COMETS School of Education 205 Bailey Hall University of Kansas Lawrence, KS 66045 telephone (913) 864-4435
When Are We Ever Gonna Have to Use This? by H. Saunders (1981) (book) ***How Math Is Used in 100 Occupations,*** by H. Saunders A poster-size matrix indicating 66 mathematics skill areas (e.g., fractions, estimation, percents, averaging, etc.) needed in 100 occupations.	Dale Seymour Publications P.O. Box 10888 Palo Alto, CA 94303-0879 telephone (800) 872-1100
Posters and Materials to Show Younger Children the Value of Mathematics and ***Sources of Materials on Careers in Mathematics***	National Council of Teachers of Mathematics 1906 Association Drive Reston, VA 22091 telephone (703) 620-9840

Title	Source of Additional Information
Exceptional Black Scientists Poster Program Five sets of free posters featuring portraits and profiles of contemporary Black scientists.	CIBA-GEIGY Corporation Corporate Relations Department 444 Saw Mill River Road Ardsley, New York 10502 telephone (914) 478-1313
Black Contributors to Science and Energy Technology Poster	U.S. Department of Energy Technical Information Center P.O. Box 62 Oak Ridge, TN 37830
Career Posters Series of multiethnic free posters relating a wide variety of careers to current interests of students.	General Electric Company Educational Communications Fairfield, CT 06430
They Used Science An interactive poster featuring six American minority persons who worked in science and health fields before the beginning of the 20th century.	Mid-Atlantic Center for Race Equity The American University 5010 Wisconsin Avenue, N.W., #310 Washington, DC 20016 telephone (202) 885-8517

Language

FORUM A free bimonthly newsletter of the National Clearinghouse for Bilingual Education.	National Clearinghouse for Bilingual Education 1555 Wilson Boulevard, Suite 605 Rosslyn, VA 22209 telephone &703) 522-0710 or (800) 336-4560
Resources for Teaching Mathematics in Bilingual Classrooms by C.J. Lovett and T. Snyder	National Council of Teachers of Mathematics Educational Materials 1906 Association Drive Reston, VA 22091 telephone (703) 620-9840
"Mathematics Learning in English as a Second Language" Article by Gilbert Cuevas in which he discusses SLAMS, an instructional model for integrating the acquisition of mathematics skills and language skills.	*Journal for Research in Mathematics Education* 15 (1984): 134–144

Bias in Instructional Materials

"10 Quick Ways To Analyze Children's Books for Racism and Sexism" A pamphlet.	The Council on Interracial Books for Children 1841 Broadway New York, NY 10023 telephone (212) 757-5339

Title	Source of Additional Information
Guidelines for Selecting Bias-Free Textbooks and Storybooks for Educators and Parents	The Council on Interracial Books for Children 1841 Broadway New York, NY 10023 telephone (212) 757-5339

Teacher Expectations

(Staff Development Programs)

Teacher Expectations and Student Performance: A Supervisory Model for School Administrators	The Mid-Atlantic Center for Race Equity The American University 5010 Wisconsin Avenue, N.W., #310 Washington, DC 20016 telephone (202) 885-8517
Teacher Expectations and Student Achievement (TESA) (1980)	Phi Delta Kappa Box 789 Bloomington, IN 47402 telephone (812) 339-1156
Shaping Teacher Expectations for Minority Girls: A Teacher Training Module	Creative Learning, Inc. 3201 New Mexico Avenue, N.W. Washington, DC 20016 telephone (202) 966-3780
Discovery Learning A process of instruction designed to motivate students, improve their self-confidence and achievement, and assist teachers with effective classroom practices. Teachers are trained to use the Socratic method to actively involve all students.	Discovery Learning, Inc. 1776 Peachtree Street, N.W. Suite 620N Atlanta, GA 30309 telephone (404) 881-8200
Active Mathematics Teaching by T.L. Good, D.A. Grouws, and H. Elomeier, 1983 A book which describes systematic research on the effectiveness of mathematics education in elementary and junior high grades. Includes a comprehensive discussion of an intervention model and teacher training.	Longman, Inc. 1560 Broadway New York, NY 10036

Learning Styles

The 4 MAT System—Teaching to Learning Styles with Right/Left Mode Techniques by B. McCarthy, 1980. (book)	EXCEL, Inc. 600 Enterprise Drive Oak Brook, IL 60521

Title	Source of Additional Information
Teacher Self-Assessment: Manual #1 in the Dealing with Diversity Series	Hanson Silver & Associates, Inc. Box 402 Moorestown, NJ 08057 telephone (609) 234-2610
Teaching Styles and Strategies: Manual #2 in the Dealing with Diversity Series	
TLC Learning Preference Inventory	
Learning Style Inventory	
Teaching Style Inventory	
"Learning Styles: Rx for Mathophobia" by H. Hodges Article introduces the environmental, emotional, sociological and physical elements of learning style. It includes a "mathophobia" assessment instrument.	*Arithmetic Teacher,* March 1983
National Learning Styles Network Provides educators with information on the research basis for and classroom implications of teaching and learning styles. A cooperative venture of the National Association of Secondary School Principals and St. John's University, New York.	Professor Rita Dunn St. John's University Grand Central Parkway Jamaica, NY 11439
Learning Style Inventory (LSI)	Price Systems P.O. Box 3217 Lawrence, KS 66044
Teaching Students Through Their Individual Learning Styles: A Practical Approach by R. and K. Dunn, 1978 (book)	Reston Publishing Company 11480 Sunset Hills Road Reston, VA 22090
Learning Styles	Title of the January 1979 issue of *Educational Leadership,* Vol. 36, No. 4
Matching Teaching and Learning Styles	Title of the Winter 1984 issue of *Theory Into Practice* (a journal of the College of Education, the Ohio State University), Vol. 23, No. 1
Learning Styles in Competency-Based Education A paper presented by Grace Campia at the East Coast Asian American Conference, April 1984.	Grace Campia Cognitive Learning Styles Specialist Boston Public Schools Humphrey Center 75 New Dudley Street Boston, MA 02119

Teacher Anxiety in Mathematics and Science

Science Anxiety and the Classroom Teacher (booklet)	National Education Association 1201 16th Street, N.W. Washington, DC 20036 telephone (202) 833-4000

Title	Source of Additional Information
The Oregon Mathematics Education Council Project designed to transform mathophobic teachers into math lovers.	Dr. Eugene Maier OMEC 325 13th Street, N.E. Unit 301 Salem, OR 97301
Overcoming Math Anxiety by Sheila Tobias, 1978 (book)	W.W. Norton & Co. 500 5th Avenue New York, NY 10110
Math Anxiety—We Beat It, So Can You (film)	Educational Development Center 55 Chapel Street Newton, MA 02160 telephone (800) 225-3088
Paths to Programs for Intervention, Resource Catalogue for Practitioners, Resource Manual for Counselors/Math Instructors	Sheila Tobias Institute for the Study of Anxiety in Learning Washington School of Psychiatry 1610 New Hampshire Avenue, N.W. Washington, DC 20009 telephone (202) 667-6380
EQUALS Training Program for Teachers Seeks to facilitate attitudinal changes in students and teachers by (1) increasing the awareness of the obstacles that math avoidance creates (2) utilizing activities that foster positive attitudes toward and increased competence in mathematics and (3) emphasizing careers which require mathematics competency	EQUALS Lawrence Hall of Science University of California Berkeley CA 94720 telephone (415) 642-1823 or contact Mid-Atlantic Center for Race Equity The American University 5010 Wisconsin Avenue, N.W., #310 Washington, DC 20016 telephone (202) 885-8517
Arithmetic Teacher Published monthly September through May, features articles for elementary teachers, reproducible activity sheets and practical activities for the classroom.	National Council of Teachers of Mathematics—Educational Materials 1906 Association Drive Reston, VA 22091 telephone (703) 620-9840
List of Resources Which Address Teachers' Anxiety in Mathematics (4 page list)	Available from National Council of Teachers of Mathematics (see preceding entry)
Science and Children Published monthly September through May, offering a wide range of classroom activities, suggestions and content information for elementary and middle school teachers.	National Science Teachers Association 1742 Connecticut Avenue, N.W. Washington, DC 20009 telephone (202) 328-5800

Title	Source of Additional Information
Summer Institutes Many states are supporting local college and university efforts to establish science programs for elementary teachers.	Check with state departments of education and postsecondary institutions in the state.

Professional Organizations

American Association for the Advancement of Science Serves as a clearinghouse for information on minorities, women and the handicapped in science.	AAAS Office of Opportunities in Science 1776 Massachusetts Avenue, N.W. Washington, DC 20036 telephone (202) 467-5438
American Association of Blacks in Energy	American Association of Blacks in Energy Dr. James E. Caldwell Standard Oil of Indiana 200 East Randolph Drive Chicago, IL 60619
American Chemical Society Will send free single copies of: ***Chemical Brainteasers—An Activity/Coloring Book*** (Grades K–4); ***A Chemical Project From Start to Finish*** (Grades 4–8); ***Chemistry in the Kindergarten through Ninth Grade Curriculum: Report with Recommendations***	American Chemical Society Education Division 1155 16th Street, N.W. Washington, DC 20036 telephone (202) 872-4600
American Indian Science and Engineering Society (AISES) Encourages programs which will increase the number of American Indian scientists and engineers.	AISES c/o A.T. Anderson, Executive Director Anderson Research Consultants, Inc. 35 Porter Avenue Naugatuck, CT 06770
Association for Puerto Ricans in Science and Engineering (APRSE)	APRSE Box 1725 Washington, DC 20013
Association for the Development and Advancement of Black Scientists and Engineers Provides speakers bureau and traveling audio-visual presentation on Blacks at work at the National Bureau of Standards	ADABSE National Bureau of Standards Building 224, Room B150 Gaithersburg, MD 20234
Association for Women in Mathematics Provides schools with majority and minority female speakers on mathematics, its applications to health and other fields, and careers.	Association for Women in Mathematics P.O. Box 178 Wellesley College Wellesley, MA 12181

Title	Source of Additional Information
Blacks in Mathematics (BAM) Provides role models and information for students, counselors, teachers and parents on mathematics-based careers.	BAM Washington DC Region c/o Department of Mathematics Howard University Washington, DC 20050
Mathematical Association of America Prepares and distributes career awareness materials for teachers, counselors and students.	Mathematical Association of America 1529 Eighteenth Street, N.W. Washington, DC 20036 telephone (202) 387-5200
Minorities and Mathematics A network of teachers, researchers, directors of special projects and representatives of associations and funding agencies. Provides information about resources which support mathematics education. Distributes newsletter semiannually.	Minorities and Mathematics Network Helen Cheek Oklahoma State University Stillwater, OK 74078 telephone (404) 624-7119
Minority Women in Science, Inc. Provides role models, career information, workshops and encouragement for minority youth. Programs include Science Teachers' Workshop and Science Discovery Day for Junior High Students.	Minority Women in Science, Inc. P.O. Box 28440 Washington, DC 20005
National Council of Teachers of Mathematics	National Council of Teachers of Mathematics 1906 Association Drive Reston, VA 22091 telephone (703) 620-9840
National Science Teachers Association	National Science Teachers Association 1742 Connecticut Avenue, N.W. Washington, DC 20009 telephone (202) 328-5800
National Society of Black Physicists	National Society of Black Physicists Dr. Shirley Jackson Bell Laboratories 600 Mountain Avenue Murray Hill, NJ 07974
Society of Hispanic Professional Engineers Works to improve the quality of education and training programs for Hispanic students entering engineering and the sciences.	Society of Hispanic Professional Engineers Rodrigo T. Garcia, Executive Director 670 Monterey Pass Road Monterey Park, CA 91756

References

Aiken, L.R., Jr. "Language Factors in Learning Mathematics." *Review of Educational Research* 42 (1972): 359–385.

Anick, C.M.; Carpenter, T.M.; and Smith, C. "Minorities and Mathematics: Results from the National Assessment of Educational Progress." *Mathematics Teacher* 74 (1982): 560–568.

Antonopolis, D.P. "Interactions of Teacher-Pupil Sex as Expressed by Teacher Expectations, Patterns of Reinforcement, and Judgments about Pupils: A National Study." *Dissertation Abstracts International* 32 (1972): 6117-A.

Baldwin, A.; Gear, G.; and Lucito, L. *Educational Planning for the Gifted.* Reston, Va.: Council for Exceptional Children, 1978.

Battle, E.S., and Rotter, J.B. "Children's Feelings of Personal Control As Related to Social Class and Ethnic Group." *Journal of Personality* 31 (1963): 482–490.

Begle, E.G. *Learning Correlates for Mexican American Students.* Washington, D.C.: Department of Health, Education and Welfare, SMSG Research and Analysis Section, 1972.

Bloom, B.S. "Talent Development vs. Schooling." *Educational Leadership* 39 (November 1981): 86–94.

Bossert, S.; Dwyer, D.; Rowa, B.; and Lee, G. "The Instructional Management Role of the Principal." *Educational Administration Quarterly* 18 (Summer 1982): 34–64.

Bredderman, T. "What Research Says: Activity Science—The Evidence Shows It Matters." *Science and Children* (September 1982): 39–41.

Brookover, W.; Beamer, L.; Efthim, H.; Hathaway, D.; Lezotte, L.; Miller, S.; Passalacqua, J.; and Tornatzky, L. *Creating Effective Schools: An Inservice Program for Enhancing School Learning Climate and Achievement.* Holmes Beach, Fl.: Learning Publications, Inc., 1982.

Brooks, S.M., and Hounshell, P.B. "A Study of Locus of Control and Science Achievement." *Journal of Research in Science Teaching* 12 (1975): 175–181.

Burow, E.D. "The Relationship Among Secondary Science Students' Locus of Control, Views of the Tentativeness of Science, Attitudes, Perceptions of Teaching Strategies, and Achievements." Ph.D. dissertation, University of Southern Mississippi, 1978. *Dissertation Abstracts International* 39 (1978): 2165-A.

Carrison, M. "Bilingual No!" *Principal* 62 (January 1983): 9, 41–44.

Coffland, J., and Cuevas, G. *Children's Learning of Number and Numerating Concepts: A Final Report.* NIE Contract No. 400-77-0074, 1979. Bethesda, Md.: ERIC Document Reproduction Service, ED 198 199.

Cohen, M., and Manasse, A. "Effective Principals." *The School Administrator* 30 (November 1982): 14–16.

Crowl, T.K. "White Teachers' Evaluation of Oral Responses Given by White and Negro Ninth Grade Males." *Dissertation Abstracts International* 31 (1971): 4540-A.

Cuevas, G. "Mathematics Learning in English as a Second Language." *Journal for Research in Mathematics Education* 15 (1984): 134–144.

DeAvila, E.; Duncan, S.; Ulbarri, D.; and Fleming, J. *Predicting the Academic Success of Language Minority Students from Developmental, Cognitive Style, Linguistic and Teacher Perceptions Measures.* Austin, Tex.: Southwest Educational Development Laboratory, 1979.

Denbo, S., and Ross, M. *The Effective Principal.* Washington, D.C.: Mid-Atlantic Center for Race Equity, The American University, 1983.

Dunn, R., and Dunn, K. "Learning Styles/Teaching Styles: Should They...Can They ...Be Matched?" *Educational Leadership* 36 (January 1979): 238–244.

Dusek, J.B. "Do Teachers Bias Children's Learning?" *Review of Educational Research* 45 (1975): 661–684.

The Effective School Report—From Research and Practice. Published monthly by Kelwynn, Inc., P.O. Box 2058, Grand Central Station, New York, N.Y. 10163.

Fauth, G., and Jacobs, J. "Equity in Mathematics Education: The Educational Leader's Role." *Educational Leadership* 36 (March 1980): 485–490.

Fennema, E. "Women and Mathematics: State of the Art Review." Paper prepared for Equity in Mathematics Core Conference, National Council of Teachers of Mathematics, Reston, Va., February 1982.

Fernandez, C.; Espinosa, R.; and Dornbusch, S. *Factors Perpetuating the Low Academic Status of Chicano High School Students.* Research and Development Memorandum No. 138. Stanford, Cal.: Stanford Center for Research and Development in Teaching, 1975. Bethesda, Md.: ERIC Document Reproduction Service, ED 110 241.

Fox, L.H. *The Problem of Women and Mathematics: A Report to the Ford Foundation.* New York: The Ford Foundation, 1980.

Gay, G. "Teachers' Achievement Expectations of and Interactions with Ethnically Different Students." *Contemporary Education* 46 (1975): 166–172.

Good, T. "Teacher Expectations and Student Perceptions: A Decade of Research." *Educational Leadership* 37 (February 1981): 415–422.

Good, T., and Brophy, J. "Teachers' Communication of Differential Expectations for Children's Classroom Performance: Some Behavioral Data." *Journal of Educational Psychology* 61 (1970): 365–374.

_____. *Looking in Classrooms.* 2nd ed. New York: Harper & Row, 1978.

Hall, P.O. *Problems and Solutions in Education, Employment and Personal Choice of Minority Women in Science.* Washington, D.C.: American Association for the Advancement of Science, Office of Opportunities in Science, 1981.

Heath, P., and Heath, P. "The Effect of Teacher Intervention on Object Manipulation in Young Children." *Journal of Research in Science Teaching* 19 (1982): 577–585.

Hilliard, A. *Alternatives to IQ Testing: An Approach to the Identification of Gifted "Minority" Children: Final Report.* San Francisco: San Francisco State University, 1976. Bethesda, Md.: ERIC Document Reproduction Service, ED 148 038.

Humphreys, B.; Johnson, R.; and Johnson, D. "Effects of Cooperative, Competitive, and Individualist Learning on Students' Achievement in Science Class." *Journal of Research in Science Teaching* 19 (1982): 351–356.

Jackson, G., and Cosca, C. "The Inequality of Educational Opportunity in the Southwest: An Observational Study of Ethnically Mixed Classrooms." *American Educational Research Journal* 11 (1974): 219–229.

Jacobowitz, T. "Relationship of Sex, Achievement and Science Self-Concept to the Science Career Preferences of Black Students." *Journal of Research in Science Teaching* 20 (October 1983): 621–628.

Joe, V.C. "Review of the Internal-External Control Construct as a Personality Variable." *Psychological Reports* 28 (1971): 619–640.

Kahle, J.B. "An Analysis of Minority Attitudes Toward Science from the 1976–77 National Assessment of Science Results." In National Assessment of Educational Progress, *Attitude Toward Science: A Summary of Results from the 1976–77 National Assessment of Science.* Report No. 08-S-02. Denver, Col.: Education Commission of the States, October 1979.

_____. "Can Positive Minority Attitudes Lead to Achievement Gains in Science: An Analysis of the 1977 National Assessment of Education Progress, Attitudes Toward Science." *Science Education* 66 (1982): 539–546.

Kamin, L. "Transcripts of Presentation to Southern-Regional Council's Symposium on Human Intelligence, Social Science, and Social Policy." *South Today* 4 (1973).

Kaser, J. *Every Child Deserves A Chance: Guidelines for Effective Teaching.* Washington, D.C.: Mid-Atlantic Center for Race Equity, The American University, 1984.

Kenschaft, P. "Black Women in Mathematics." *American Mathematical Monthly* 88 (1981): 592–604.

Lefcourt, H.M. "Internal Versus External Control of Reinforcement: A Review." *Psychological Bulletin* 65 (1966): 206–220.

_____. *Locus of Control: Current Trends in Theory and Research.* Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Leon, G.R. "Personality Change in the Specially Admitted Disadvantaged Student After One Year in College." *Journal of Clinical Psychology* 30 (1974): 522–528.

Lortie, D. "Elementary Principals in Suburbia: An Occupational and Organizational Study." Draft report to the National Institute of Education, 1982. Cited by Cohen, M., and Manasse, A. in "Effective Principals." *The School Administrator* 30 (November 1982): 14–16.

Maben, J.W. "Is There Hope for School Science in the 1980's?" *The National Elementary Principal* 59 (January 1980): 37–43.

Maestas, S. "Sociocultural Factors As a Deterrent to Students' Pursuit of the Sciences." In V.L. Melnick and F.D. Hamilton, eds. *Minorities in Science: The Challenge for Change in Biomedicine.* New York: Plenum Press, 1977.

Malcom, S.; Hall, P.; and Brown, J. *The Double Bind: The Price of Being a Minority Woman in Science.* Report No. 76-R-3. Washington, D.C.: American Association for the Advancement of Science, 1976.

Matthews, W.L. *Race and Sex-Related Differences in High School Mathematics Enrollment.* Ph.D. dissertation, University of Chicago, 1980. *Dissertation Abstracts International* 41 (1980): 3934-A.

_____. "Influences on the Learning and Participation of Minorities in Mathematics." *Journal for Research in Mathematics Education* 15 (1984): 84–95.

_____. "Adding Up Minorities and Mathematics." Unpublished manuscript, 1981.

McMillan, J. "Effect of Instructional Procedure and Pupil Locus of Control on Achievement and Attitudes." *Psychology in the Schools* 17 (1980).

Mechling, K., and Oliver, D. *Handbook II: The Principal's Role in Elementary School Science.* Washington, D.C.: Project for Promoting Science Among Elementary School Principals, National Science Teachers Association, 1983.

_____. *Handbook IV: What Research Says About Elementary School Science.* Washington, D.C.: Project for Promoting Science Among Elementary School Principals, National Science Teachers Association, 1983.

Mestre, J.; Gerace, W.; and Lockhead, J. "The Interdependence of Language and Translational Math Skills among Bilingual Hispanic Engineering Students." *Journal of Research in Science Teaching* 19 (1982): 399–410.

National Assessment of Educational Progress (NAEP). *A Summary of Results from the 1976–77 National Assessment of Science* Report No. 08-5-01. Denver, Col.: Education Commission of the States, 1979.

National Assessment of Educational Progress (NAEP). *The Third Mathematics Assessment: Results, Trends, and Issues.* Denver, Col.: Education Commission of the States, April 1983.

The National Science Board Commission on Precollege Education in Mathematics, Science and Technology. *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All American Elementary and Secondary Students So That Their Achievement Is the Best in the World by 1995.* (a) A Report to the American People and the National Science Board; (b) Source Materials. Washington, D.C.: National Science Board, National Science Foundation, 1983.

National Science Foundation. *Women and Minorities in Science and Engineering.* Washington, D.C.: National Science Foundation, 1984.

Office of Opportunities in Science, American Association for the Advancement of Science. "An Assessment of Programs That Facilitate Increased Access and Achievement of Females and Minorities in K–12 Mathematics and Science Education: A Study Conducted for the National Science Board Commission on Precollege Education in Mathematics, Science and Technology." Washington, D.C.: American Association for the Advancement of Science, July, 1983.

Olstad, R.; Juarez, J.; Davenport, L.; and Haury, D. *Inhibitors to Achievement in Science and Mathematics by Ethnic Minorities.* Bethesda, Md.: ERIC Document Reproduction Service, ED 223 404, 1981.

Ortiz-Franco, L. "A Synthesis of Selected Research at NIE in Mathematics Related to Minorities." Unpublished manuscript, 1981.

Peng, S.S.; Fetters, W.B.; and Kolstad, A.J. *High School and Beyond: A National Longitudinal Study for the 1980's.* Washington, D.C.: National Center for Education Statistics, 1981.

Ponzio, R. "Science Education for the Eighties: Minority Participation." Paper presented at the Annual Meeting of the American Educational Research Association, Los Angeles, Cal., April 1981. Bethesda, Md.: ERIC Document Reproduction Service, ED 201 534, 1981.

Pulos, S.; Stage, E.; and Karplus, R. "Setting Effects in Mathematics Reasoning of Early Adolescents: Findings from Three Urban Schools." *Journal of Early Adolescence* 2 (1982): 39–59.

Ramirez, M.; Castaneda, A.; and Herold, P. "The Relationship of Acculturation to Cognitive Style Among Mexican-Americans." *Journal of Cross-Cultural Psychology* 15 (1974): 424–433.

Reyer, L.H., and Weller, L.D. "Stereotyping: Impact on Teachers and Students." *Action in Teacher Education* 5 (Fall 1983): 1–7.

Rist, R.C. "Student Social Class and Teacher Expectations: The Self-Fulfilling Prophecy in Ghetto Education." *Harvard Educational Review* 40 (1970): 411–451.

Rodriguez, I., and Bethel, L. "An Inquiry Approach to Science and Language Teaching." *Journal of Research in Science Teaching* 20 (April 1983): 291–296.

Rosenbaum, J.E. *Making Inequality: The Hidden Curriculum of High School Tracking.* New York: John Wiley & Sons, 1976.

Rosenthal, R., and Jacobson, L. *Pygmalion in the Classroom: Teacher Expectations and Pupils' Intellectual Development.* New York: Holt, Rinehart & Winston, 1968.

Rotter, J.B. "Generalized Expectations for Internal Versus External Control of Reinforcement." *Psychological Monographs* 80 (1966).

Rowe, M.B. *Teaching Science as Continuous Inquiry.* (Chapter 9: "Wait Time—Is Anybody Listening?" Chapter 10: "Science and Sanctions," Chapter 11: "Science and Soul: Some Musing on Fate Control.") New York: McGraw-Hill Book Co., 1978.

_____. "Relation of Wait-Time and Rewards to the Development of Language, Logic, and Fate Control: Part II—Rewards." *Journal of Research in Science Teaching* 11 (1974): 291–308.

_____. "Why Don't Blacks Pick Science?" *The Science Teacher* 44 (1977): 34–35.

Rubovits, P., and Maehr, M. "Pygmalion Black and White." *Journal of Personality and Social Psychology* 25 (1973): 210–218.

Science Assessment and Research Project, University of Minnesota. *Images of Science.* Minneapolis: Minnesota Research and Evaluation Center, 1983.

Sells, L. "Mathematics—A Critical Filter." *The Science Teacher* 75 (1978): 28–29.

Shymansky, J.; Kyle, W.; and Alport, J. "How Effective were the Hands-On Science Programs of Yesterday?" *Science and Children,* November/December 1982, pp. 14–15.

Smith, L. *Mathematics Education in an American Indian Culture.* Tempe, Ariz.: Arizona State University, 1981.

Thomas, G.E. *Math Readiness and Preparation for Competitive College Majors and Careers: The Case of Black Students.* Baltimore, Md.: Center for Social Organization of Schools, Johns Hopkins University, 1983.

Treisman, P. "Helping Minority Children to Excel in University-Level Mathematics and Science Courses." Berkeley, Cal.: University of California, Professional Development Program, 1982.

Trevino, B. "An Analysis of the Effectiveness of a Bilingual Program in the Teaching of Mathematics in the Primary Grades." Ph.D. dissertation, University of Texas at Austin, 1968. Cited by Valverde, L., "Hispanic Students and Mathematics: Research Findings and Recommendations." Paper presented at the Equity in Mathematics: Core Conference, The National Council of Teachers of Mathematics, Reston, Va., February 1982.

Troike, R. "Bilingual Si!" *Principal* 62 (January 1983): 8, 46–50.

Valverde, L.A. "Underachievement and Underrepresentation of Hispanics in Mathematics and Mathematics-Related Careers." *Journal*

for Research in Mathematics Education 15 (1984): 123–133.

Washington, V. "Racial Differences in Teacher Perceptions of First and Fourth Grade Pupils on Selected Characteristics." *The Journal of Negro Education* 51 (Winter 1982): 60–72.

Witkin, H.; Moore, C.; Goodenough, D.; and Cox, P. "Field-Dependent and Field-Independent Cognitive Styles and Their Educational Implications." *Review of Educational Research* (Winter 1977): 1–64.

Woodworth, W.P., and Salzer, R.T. "Black Children's Speech and Teacher Evaluations." *Urban Education* 6 (July 1971): 167–173.

APPENDIX

TABLE I
Mathematics and Science Courses of High School Seniors by Racial/Ethnic Group and Course Title: 1980 (Percent)

Course	White	Black	Asian	Native American	Hispanic
Algebra I	81	68	88	61	67
Geometry	60	38	79	34	39
Algebra II	50	39	76	32	38
Trigonometry	27	15	50	17	15
Calculus	8	5	22	5	4
Chemistry	39	28	59	24	26
Physics	20	19	35	17	15

Reprinted with permission from National Center for Education Statistics, *High School and Beyond: A National Logitudinal Study for the 1980's* (Washington, D.C., 1981), p. 5.

TABLE II
Scholastic Aptitude Test (SAT) Scores for College-Bound Seniors by Race/Ethnic Group: 1976–82

Race/ethnic group	1976		1977		1978		1979		1980		1981		1982	
	Verbal	Math	Verbal	Math	Verbal	Math	Verbal	Math	Verbal	Math	Verbal	Math	Verbal	Math
Total	431	472	429	470	429	468	427	467	424	466	424	466	426	467
White	451	493	448	489	446	485	444	483	442	482	442	483	444	483
Black	332	354	330	357	332	354	330	358	330	360	332	362	341	366
Asian	414	518	405	514	401	510	396	511	396	509	397	513	398	513
Native American	388	420	390	421	387	419	386	421	390	426	391	425	388	424
Mexican American	371	410	370	408	370	402	370	410	372	413	373	415	377	416
Puerto Rican	364	401	355	397	349	388	345	388	350	394	353	398	360	403
Other	410	458	402	457	399	450	393	447	394	449	388	447	392	449

Reprinted with permission from L. Blemiller, "Board Says Minority-Group Scores Helped Push Up Averages on SAT," *Chronicle of Higher Education*, 25 (October 20, 1982) :1 and 10.

TABLE III
Changes in Mean Performance on the Mathematics Assessment by Racial/Ethnic Group: 1978–82

Race/ethnic group and age	Overall performance		Knowledge		Skills		Understanding		Applications	
	Score (1982)	Change (1978-82)	Score (1982)	Change (1978-82)	Score (1982)	Change (1978-82)	Score (1982)	Change (1978-82)	Score (1982)	Change (1978-82)
Total										
9-year olds	56.4%	+1.0%	68.3%	+1.4%	50.6%	+0.8%	41.2%	−0.4%	39.6%	+0.5%
13-year olds	60.5	+3.9[1]	73.8	+4.5[1]	57.6	+4.0[1]	60.5	+3.9[1]	45.6	+2.2[1]
17-year olds	60.2	−0.2	74.9	+0.2	60.0	+0.3	61.5	−0.3	42.4	−1.1
White										
9-year olds	58.8	+0.7	70.8	+1.2	53.1	+0.6	43.4	−0.8	42.4	+0.6
13-year olds	63.1	+3.2[1]	76.1	+3.9[1]	60.4	+3.4[1]	63.6	+3.6[1]	47.9	+1.6[1]
17-year olds	63.1	−0.2	77.3	0.0	63.0	+0.3	64.7	−0.1	45.5	−1.0
Black										
9-year olds	45.2	+2.1	57.8	+3.5[1]	38.7	+1.6	31.4	+0.9	27.0	−0.6
13-year olds	48.2	+6.5[1]	63.8	+8.0[1]	44.0	+6.7[1]	46.4	+5.9[1]	34.8	+4.4[1]
17-year olds	45.0	+1.3	62.6	+3.0	44.2	+1.8	44.8	−0.2	26.0	−0.2
Hispanic										
9-year olds	47.7	+1.1	58.7	0.0	43.8	+2.5	32.4	−0.2	30.5	+0.6
13-year olds	51.9	+6.5[1]	65.3	+6.3[1]	49.2	+7.2[1]	49.7	+5.9[1]	38.8	+6.0[1]
17-year olds	49.4	+0.9	66.1	+2.0	48.4	+0.5	49.7	+0.8	31.4	+0.4

[1]Change is significant at 0.05 level.

National Assessment of Educational Progress, *The Third National Mathematics Assessment Results, Trends and Issues* (Report No. 13-MA-01), April 1983, pp. 34 and 51. Reprinted with permission from Educational Testing Service.

TABLE IV
Changes in Mean Performance for Males and Females on the Science Assessment by Race: 1977–82

Assessment component	Males						Females					
	White			Black			White			Black		
	9-year olds	13-year olds	17-year olds	9-year olds	13-year olds	17-year olds	9-year olds	13-year olds	17-year olds	9-year olds	13-year olds	17-year olds
Inquiry												
Score (1982)	55.9%	60.4%	72.8%	40.8%	48.8%	58.1%	55.3%	59.7%	71.6%	41.4%	49.3%	56.7%
Change (1977-82)	− 1.3%	− 0.8%	− 2.6%[2]	+ 3.4%	+ 0.6%	− 0.1%	− 1.7%	− 1.1%	− 2.5%[2]	+ 1.9%	+ 0.1%	− 1.9%
Science-Technology-Society												
Score	62.7	61.5	71.2	50.7	50.1	55.8	61.3	57.4	67.8	51.7	46.8	54.1
Change	+ 3.0[2]	+ 0.7	− 1.2	+ 4.4	+ 1.5	+ 0.3	+ 2.2	+ 0.4	+ 0.2	+ 4.3	− 0.8	+ 2.0
Content												
Score	(1)	56.8	65.6	(1)	44.6	47.8	(1)	52.4	59.3	(1)	40.6	44.4
Change		− 0.2	− 1.7		+ 2.4	− 1.8		− 1.2	− 1.6		− 0.8	− 1.3
Attitude[3]												
Score	68.6	52.6	48.0	64.1	53.8	53.8	66.2	47.0	45.4	61.4	50.0	54.5
Change	− 1.1	− 3.2[2]	− 1.3	+ 1.4	+ 0.8	− 0.4	− 0.5	− 2.6[2]	+ 3.0[2]	− 0.2	− 1.7	+ 2.0

[1]Not administered at 9-year old level.
[2]Change is significant at the 0.05 level.
[3]For 13 and 17-year olds, "attitude" refers only to "attitudes toward science classes."

Reprinted with permission of Science Assessment and Research Project, University of Minnesota, *Images of Science* (Minneapolis, MN: Minnesota Research and Evaluation Center, June 1983), pp. 101-119.

TABLE V
On Campus Recruitment, Average Opening Job Offers From January 1981 By Field and Mathematics Requirement

Undergraduate Curriculum	Number of Job Offers	Percentage of Offers	Mean Size of Offers Monthly	Mean Size of Offers Yearly
"Hard" Calculus Fields:				
Engineering	6,183	62%	$1,855	$22,260
Hard Sciences	626	6	1,615	19,380
"Soft" Calculus Fields:				
Business & Management	2,664	27	1,354	16,248
Economics	58	1	1,242	14,904
Agriculture, Biology, and Health Sciences	195	2	1,229	14,748
"No Calculus" Fields:				
Humanities	105	1	1,058	12,696
Social Sciences	160	2	1,047	12,564
Total Offers and Average Size	9,991	100%	$1,669	$20,028

Source: Adapted by Lucy W. Sells from College Placement Council (CPC), 1981. The beginning salary data reported are based on offers (not acceptances), to graduating seniors in select curricula and graduate programs during the normal college recruiting periods, September to January 1981. The CPC survey covers job openings in a broad range of functional areas, *except teaching*, within business, industry and government. The data are submitted by a representative group of colleges throughout the United States.

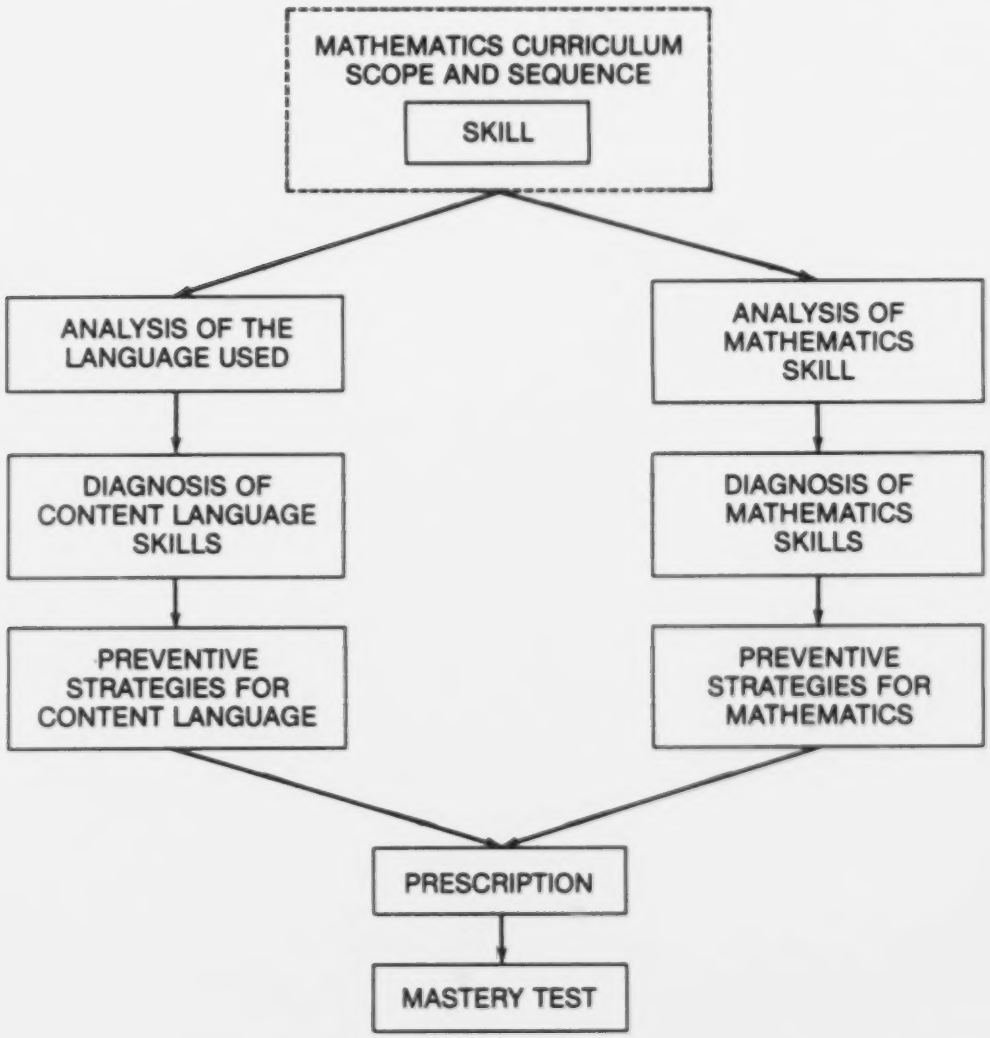
Reprinted with permission of California Post Secondary Education Commission, *Equal Educational Opportunity in California Post Secondary Education*, Part IV (April, 1982).

TABLE VI
SAT Averages and Average Family Income for 1973–74 College Bound Seniors

SAT Average	Average Income
750–800	$24,124
700–749	$21,980
650–699	$21,292
600–649	$20,330
550–599	$19,481
500–549	$18,824
450–499	$18,122
400–449	$17,387
350–399	$16,182
300–349	$14,355
250–299	$11,428
200–249	$ 8,639

Adapted from *Test Scores and Family Income* (Princeton: Educational Testing Service, February 1980), p. 7. Printed with permission from Educational Testing Service.

Instructional Model for Second Language Approach to Mathematics Skills (SLAMS)



Reprinted with permission from Gilberto Cuevas, "Mathematics Learning in English as a Second Language," *Journal for Research in Mathematics Education* 15 (1984): 141.

National Science Board Commission on Precollege Education in Mathematics, Science and Technology

Suggestions for Course Topics and Criteria for Selection

In preparing an outline of topics and criteria, the Commission has been fortunate to have the advice of experts who have spent much time developing materials and contributing to conferences on elementary and secondary mathematics, science and technology education. The Commission is confident that the thrusts of the recommendations from these conferences go in appropriate directions. Some suggested course topics from Commission-sponsored meetings and other groups and professionals are cited in this section.

At the same time, it is one thing to give a list of the ideas and objectives desired, and another to create the courses appropriate to pupils in a specific school system in such a way that an integrated educational program results. Such programs require substantial work by groups of professionals at all levels. No one course of study is appropriate for all students and all teachers in all schools in all parts of the country. Nor is there just one good curriculum. Various parts of the Nation must develop their total curriculum and revise it repeatedly to keep it suitable for students and teachers. We hope this paper and the cited references will help with the process.

In the fields of mathematics and science, we have many more years of experience in curriculum development than we do in the area of technology, where clearly special efforts are required. Technology is a part of everyone's daily life. Even so, most people do not appreciate the complexity of our technological society. Yet, a key to understanding problems among nations, communities, and individuals can be found through our actions in producing goods and services. The needs of today demand useful inventions, productive research, efficient production, quality workmanship, and personalized service. To achieve these goals, we must begin to develop our human resources in the elementary and secondary schools through a comprehensive, contemporary, technology education for all.

Computers and related software systems are developing at a great rate. These developments must go well beyond speeding arithmetic work or electronic page turning. Computers can effectively be integrated into virtually all teaching and learning areas such as the teaching of reading, development of graphing techniques, development of skills in composition and development of physical insights through modeling and interaction with the real world.

Creating better computer programs and uses to assist with learning should proceed in parallel with curriculum development. For this technology to have an appropriate impact on our schools and national economic program, it will require close and continuing attention and development.

To conduct cirriculum development as though the disciplines exist independently of each other does an injustice to the natural and necessary integration of mathematics, science and technology. However, for obvious and practical reasons we have addressed course topics under the headings involving mathematical sciences, the natural sciences (further divided into physics, chemistry and biology) and technology. Such a presentation does not necessarily recommend classroom delivery through these same categories. Rather, we hope that teachers of mathematics, the natural and social sciences, technology, of reading and writing, history, English and the arts, will seize the numerous opportunities to demonstrate the interdependence of human knowledge and encourage students to apply the skills and concepts from one discipline in seeking solutions in the others.

Caution

We know some students in secondary school do not display special talent in mathematics or may have difficulties stemming from poor preparation; many others are not headed for careers in the sciences or technology. For these

reasons, suggested topics should be considered in view of student needs and skills and modified accordingly to allow all students to benefit from their knowledge of science and technology and for all to reach their highest potential. Courses encompassing important mathematics principles must be developed to meet the needs of these students. We urge the consideration of computers as both mathematical tools and facilitators of learning. They can offer a fresh window into learning for the average student.

K-8 Mathematics

The Commission recommends changes that are fairly substantial, but at this level they are primarily in emphasis rather than in overall content. When implemented, the desired changes at the K-3 level lead to even more significant improvements at the 4-6 and 7-8 grade levels. The changes de-emphasize excess drill in formal paper and pencil computations and provide various procedures to develop better number sense on the part of the student. We must design instruction to build upon the young child's innate numbers sense. Mathematics education must try to develop confidence and minimize "math anxiety." We feel that the desired changes will bring a new sense of vitality to mathematics education.

Instruction at the K-8 level should be designed to achieve the following outcomes:

- Understanding of arithmetic operations and knowledge of when and where specific operations should be used.
- Development of a thorough understanding of and facility with one digit number facts.
- Ability to use selectively calculators and computers to help develop concepts and to do many of the tedious computations that previously had to be done by using paper and pencil.
- Development of skill in the use of informal mental arithmetic, first in providing exact answers to simple problems and later, approximate answers to more complicated problems.
- Development of skills in estimation and approximation.
- Development of problem-solving abilities. Trial and error methods, guessing and guestimating in solving word problems should be actively encouraged at all levels.
- Understanding of elementary data analysis, elementary statistics, and probability.
- Knowledge of place value, decimals, percent, and scientific notation.
- Understanding of the relationship of numbers to geometry.
- Understanding of fractions as numbers, comparison of fractions, and conversion to decimals.
- Development of an intuitive geometric understanding and ability to use the mensuration formulas for two- and three-dimensional figures.
- Ability to use the concepts of sets and some of the language of sets where appropriate. However, sets and set language are useful tools, not end goals, and it is inappropriate to start every year's program with a chapter on sets.
- Understanding of elementary function concepts including dynamic models of increasing or decreasing phenomena.
- Ability to use some algebraic symbolism and techniques, particularly in grades 7-8....

Science

The desired outcomes of science instruction involve understanding the appreciation of the external and internal biological and physical environments. Such learning must clearly be a lifelong process. Thus, there are many choices as to what topics are to be included from science and technology in elementary and secondary school education, whereas, in mathematics, there is a generally accepted sequence to provide essential building blocks.

The desired outcomes of science and technology involve various levels of rigor in topics and the stimulation of student interest to continue science and technology study throughout a lifetime. In the early years, students should have many opportunities to experience science in a real world (laboratory) context in a manner that does not separate the sciences into biological and physical science. The natural environment of the community and school can also be used as a laboratory setting. In the later

years of high school, specialized courses will naturally be provided for those students especially motivated to pursue one or more of the science areas in greater depth.

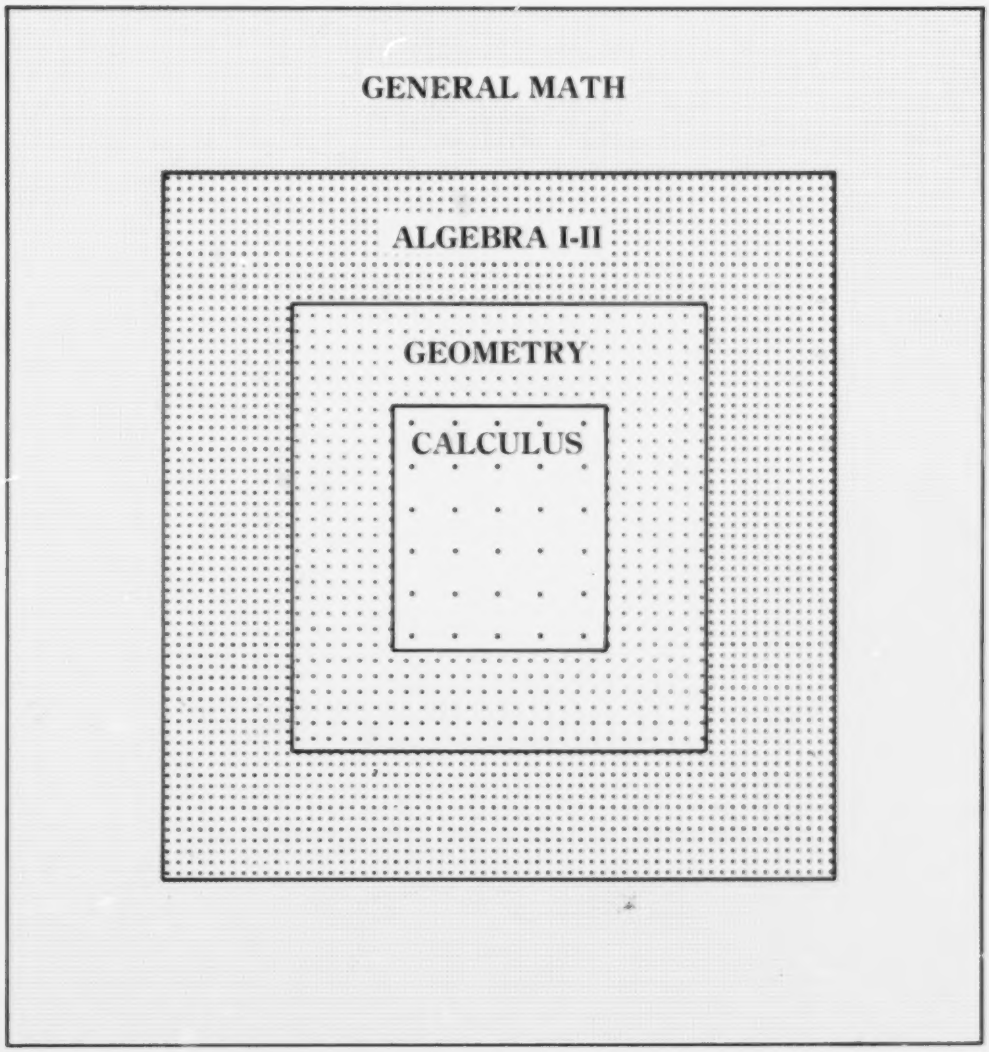
Instruction in the sciences and technology in grades K-5 should be designed to achieve the following outcomes:

- Knowledge of phenomena in the natural environment and opportunities to use applicable arithmetic in the learning of science. In addition, the integration of science with the teaching of reading and writing should be actively pursued.
- Growth in the natural curiosity of children about their physical and biological surroundings.
- Ability to recognize problems, develop procedures for addressing the problem, recognizing, evaluating and applying solutions to the problem.
- Personal experiences with appropriate level hands-on science activities with both biological and physical phenomena.
- Ability to use appropriate level mathematics in describing some science and in solving science problems.
- Ability to communicate, orally and in writing, observations of and experiences with scientific phenomena.
- Some knowledge of scientific and technical careers and of the necessary background for continued study in these areas.

Instruction for students in grades 7 and 8 should place emphasis on the biological, chemical and physical aspects related to the personal needs of adolescents; and to the development of qualitative analytical skills. Instruction at this level should continue to build on students' earlier experiences and be designed to achieve the following outcomes through experimentation, text and community resources:

- An understanding of how their own bodies function.
- Recognition of societal issues related to science and technology.
- Development of greater skill in observing, classifying, communicating, measuring, hypothesizing, inferring, designing investigations and experiments, collecting and analyzing data, drawing conclusions and making generalizations.
- Growth in problem-solving and decision-making abilities.
- Ability to ask questions, manipulate variables, make generalizations and refine concepts.
- A beginning understanding of the integration of the natural sciences, social sciences and mathematics.
- Familiarity with the usefulness of integrating technologies (calculator, computer, cable television) with experiences in the sciences.
- Appreciation of local resources such as museums, scientists and specialists to extend learning experiences beyond the school walls and hours.
- Continued development of a sense of a potential science role in career or life choices....

*Reprinted with permission from The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All American Elementary and Secondary Students So That Their Achievement Is the Best in the World by 1995: A Report to the American People and the National Science Board* (Washington, D.C.: National Science Foundation, 1983).



THE AMERICAN UNIVERSITY
WASHINGTON, DC

The American University is an Equal Opportunity/Affirmative Action Employer.

BEST COPY AVAILABLE